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General correspondence concerning membership and editorial matters should be addressed to the secretary; Peter Bellwood, Department of Prehistory and Anthropology, Australian National University, Box 4 P.O., Canberra, A.C.T. 2600 Australia.

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EDITORIAL

Two international conferences this year have carried sessions on Indo-Pacific archaeological topics; the 15th Pacific Science Congress held in Dunedin in February, and the 11th International Congress of Anthropological and Ethnological Sciences held in Vancouver in August. When publication details are known they will be announced via the Bulletin or Newsletter.

The Centre of Asian Studies in Hong Kong will commence publication of an East Asian Tertiary-Quaternary Newsletter, to carry articles on the palaeoenvironmental disciplines together with floral and faunal (including human) evolution in the East Asian region (20° - 50° N; 80° - 150° E). The mailing list is being handled by Dr Edward K.Y. Chen, Director, Centre of Asian Studies, Hong Kong, and the editor is Dr Catherine Badgley, Museum of Palaeontology, University of Michigan, Ann Arbor, Michigan 48109, USA.

The National Research Centre of Archaeology of Indonesia has published many archaeological items in recent years in the following series;

Bulletin of the Research Centre of Archaeology of Indonesia
(in English)

Berita Penelitian Arkeologi
(in Indonesian)

Aspek-Aspek Arkeologi Indonesia
(in English)

Kalpataru
(in Indonesian)

Amerta
(in Indonesian)

Details of these and other recent publications can be obtained from the Pusat Penelitian Arkeologi Nasional, P.O. Box 292 KBY, Jakarta Selatan, Indonesia.

I hope to print bulletin 5 in mid-1984, and I hope anyone reading this who has a piece of research well underway or completed in any IPPA region will send me a manuscript. Please limit your contributions to under 15 pages of double-spaced typing; line drawings are acceptable, but not photographs. Please follow the World Archaeology format for references.

PETER BELLWOOD

ERRATUM FOR BULLETIN 3

Matthew Spriggs has informed me that Table 1 of the article by G.S. Hope and M.J.T. Spriggs, "A Preliminary Pollen Sequence from Aneityum Island, Southern Vanuatu", published in Bulletin 3 page 89, was originally submitted with errors. The correct version is as follows:

Layer	Depth from Surface (cm)	Layer Description
1	0-15	Black saturated peaty material, many roots and plant debris.
2	15-35	Black and brown saturated clayey material, mottled, many roots. This represents a phase of rapid deposition. A date on the fine mud fraction from 20-30 cm depth gave an age of 2940±80 BP (ANU-2421b).
3	35-70	Saturated, mainly peaty layer, numerous roots. A C14 sample of wood and leaf fragments from 45-60 cm gave a date of 3740±170 BP (ANU-2420).
4	70-100	Saturated slightly sandy material containing numerous roots and preserved plant material including *Cocos nucifera* endocarp fragments. A C14 sample of coconut endocarp found at 90-100 cm gave a date of 5410±100 BP (ANU-2419).
5	100-145	Saturated sandy material with abundant preserved plant debris including *in situ* *Cocos nucifera* roots as well as endocarp fragments. Coconut endocarp at 115 cm gave a date of 5420±90 BP (ANU-2418).
6	145-175	Saturated sand with some hard beachrock fragments and some *in situ* coconut roots. A C14 sample on coconut roots from 160-170 cm gave a date of 5040±370 BP (ANU-2417). No shell or coral fragments were encountered.

Table 1: AT556, Anawau Swamp, Anelcauhat, layer description.

ADAPTATION PATTERNS DURING THE LATE STONE AGE IN BASTAR DISTRICT, MADHYA PRADESH

Zarine M. Cooper
Deccan College
Pune

Microlithic industries constitute the most well-represented phase of the Stone Age in India. They occur in stratified as well as surface contexts. In number, the surface occurrences exceed the stratified sites, although the information obtained from the former generally tends to be meagre and insignificant when compared to that gleaned from excavations such as Bhimbetka and Adamgarh in Madhya Pradesh (Misra et al. 1977; Joshi 1978), Bagor in Rajasthan (Misra 1973), and Sarai Nahar Rai and Mahadaha in Uttar Pradesh (Sharma 1973; Sharma et al. 1980).

To add to the disadvantages of shallow surface stations the acidic soil conditions in a majority of areas do not allow organic remains to be preserved, and this greatly hinders the process of interpreting prehistoric subsistence patterns. In recent years, however, a number of studies of surface sites (e.g. Jacobson 1980; Murty 1981) have demonstrated their potential for providing valuable insights into the past.

The discovery of 49 microlithic assemblages in east-central Bastar, the southernmost district of Madhya Pradesh, has provided another opportunity to understand the significance of such sites.

SALIENT FEATURES OF THE BASTAR MICROLITHIC INDUSTRY

1. The study area covers 107.52 sq. km. around the Chitrakot Falls, along the Indravati river. The sizes of the sites range from over 20,000 sq. m. down to 25 sq. m. or less.

2. All the sites are located within one kilometre of perennial sources of water, that is, along the Indravati river and the major streams draining into it. It is interesting to note that the settlements of the Kuruk fishermen who now inhabit this area are contiguous with the Stone Age sites.

3. Over 90% of the Bastar industry consists of chipped waste such as flakes, cores, worked and unworked pebbles, and chips. The blades can be divided into two categories, namely retouched and unretouched pieces. The former comprise crescents, blades blunted on one straight edge, points, triangles, and a few obliquely truncated and penknife blades. Among blades as a whole, however, about 55-60% are simple, unretouched, parallel-sided bladelets. Scrapers only constitute 0.3% of the assemblages, and burins and borers are conspicuously absent.

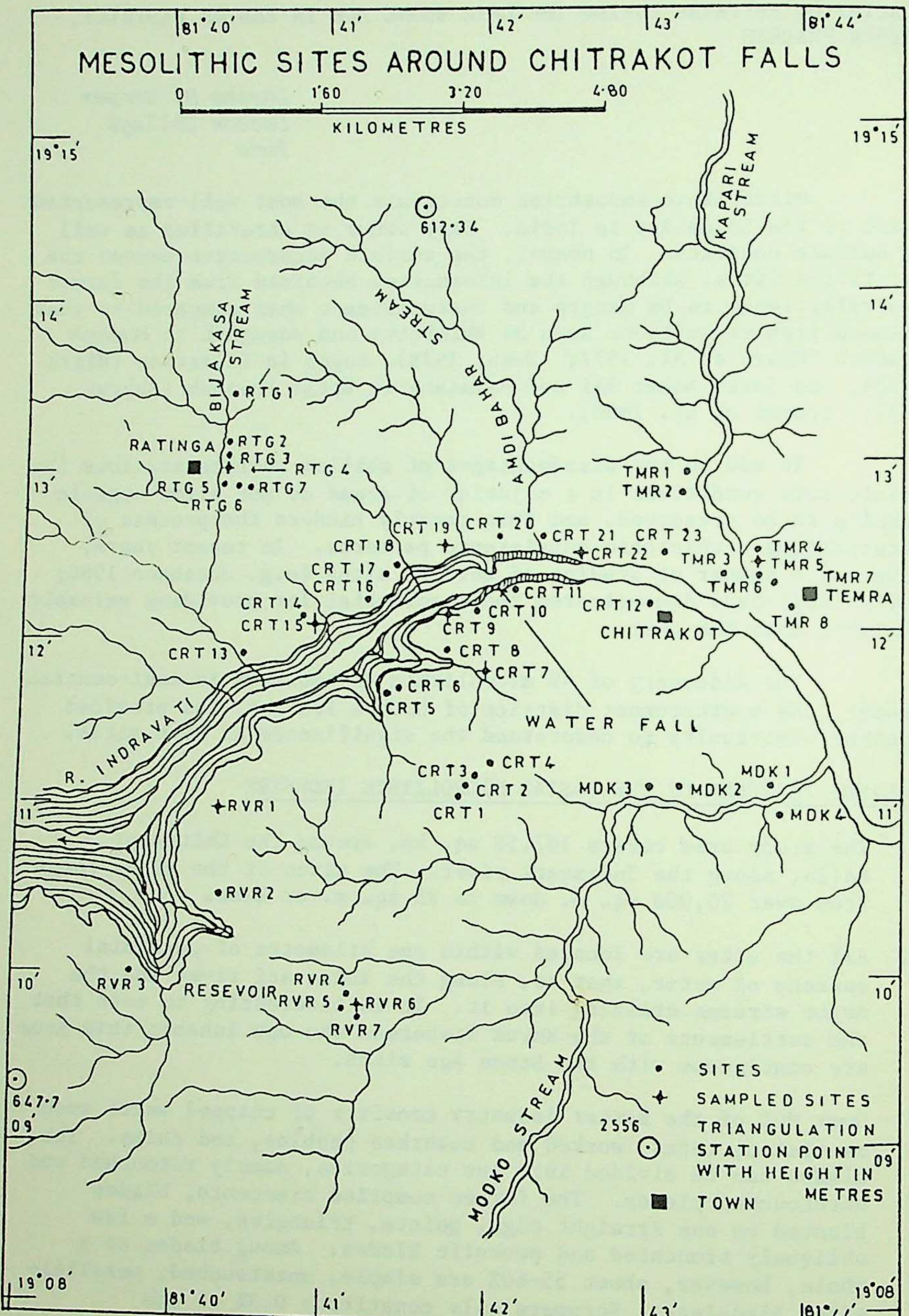

Figure 1. Mesolithic Sites around Chitrakot Falls.

4. Quartz is the predominant raw material used, while chert, quartzite, and chalcedony are represented in smaller quantities.

5. On typological grounds, as well as from the absences of pottery, metal objects, or any other features associated with early farming communities, the industry around Chitrakot has been ascribed to the Mesolithic, although it is difficult to say whether it belongs to an earlier or later phase of this period.

THE ENVIRONMENT

In this study, a survey of the environment has played a key role in helping to identify the factors that might have determined land use and the patterns of settlement in the past. The plateau topography is formed by the horizontally disposed, resistant quartzites and sandstones which occur as a capping over the older Archaean metamorphics. The quartzitic sandstones are interbedded with shales that have generally been eroded away where exposed at the surface.

Wherever the basal sandstone has been exposed the artifacts are generally concentrated in clusters in rocky depressions, although on the isolated exposures of shale they occur in fairly even scatters. On the sites examined so far the depth of soil varies from 10-40 cm., and microliths occur both on and below the surface. Hoever, stream and river sections in this particular area are devoid of artifacts.

The courses of major streams are controlled by fracture lines and they form deep gorges before they join the Indravati river. By far the steepest and widest gorge has been cut by the Indravati itself as it plunges off the North-Eastern Plateau to form a magnificent horseshoe waterfall at Chitrakot. The height of the waterfall is 28.5 metres and the immense pool that it forms is 183 metres wide.

In terms of the richness of the biome there are no other ecozones in the Indravati valley that parallel the Chitrakot Falls and the gorge, for here one can find over 35 species of wild edible plants and a variety of animal life. The river contains 43 species of fish of which at least 13 have been identified at Chitrakot.

The vegetation is of mixed deciduous type, although certain species are found only along the watercourses. For example, edible plants like the 'chiur' grass (Cryptocoryne retrospiralis) grow in great profusion in the gorge throughout the dry season.

From the point of view of the availability of lithic raw material the sandbars in the gorge are one of the main sources. A few kilometres further upstream, on the northern bank near the village of Temra, large nodules of chert lie embedded within the shale, and in numerous places they have been exposed by erosion.

With regard to the accessibility of food and water, sites generally overlook spots where the sides of the gorge have crumbled to form a natural stairway to the sandbars, and they also occur along streams at places where they can be easily crossed but which are free from overflooding during the monsoon. When viewed in the light of these facts, it is hardly surprising to find that well-worn footpaths traverse the open-air stations and are regularly used by the villagers.

METHODS OF STUDYING THE SITES

The main aim of this research project was to find an explanation for the high density of sites in this area, especially along the watercourses, and to try to explain the predominance of flaked waste or debitage. The process of investigation involved selecting 9 sites (CRT-7, CRT-9, CRT-15, CRT-19, CRT-22, RTG-4, RVR-1, RVR-6, TMR-5) which were considered representative of the different environments in the study area. The selected sites were first mapped, and it was noted that the artifacts occurred either in discrete clusters or in more diffuse scatters over the soil. On each site, about 25% of the clusters were then chosen at random and sampled.

The total number of clusters thus sampled was 239, and they had an average size of 1.20 sq. m. It was observed that in 65% of the clusters the soil cover was 2 cm. or more in depth, enough to support a scanty grass cover that would have reduced the degree of displacement of the artifacts.

MAIN RESULTS OF THE STUDY

In the initial stages of the study, two facts helped to disprove the hypothesis that the sites were essentially factory or workshop stations.

1. In the first place, the sites located along the gorge and those near Temra (the two principal sources of quartz and chert, respectively) do not have higher percentages of debitage than those situated father away from these two sources. Moreover, the greater proximity of some assemblages to these sources has not resulted in a predominance of either quartz or chert.

2. Secondly, there are no microliths or any habitational evidence in the caves and rock shelters around Michanar, 15 km to the south of Chitrakot. This suggests that the principal area of habitation during the Mesolithic is likely to have been close to the river. The locations and sizes of the sites, therefore, seem to have

depended more upon the opportunities for exploitation available in the different ecozones along the river valley than upon the occurrences of lithic raw materials.

3. One of the most interesting facts that has emerged from the typological analysis concerns the dichotomy in the types of blades. Although, when considered collectively, there are larger numbers of plain or unretouched blades than retouched, the former apparently did not serve as blanks that were meant to be worked to the required dimensions. In fact, the unretouched blades appear to be a distinct class of tool since most of them are made of chert, while the majority of the retouched blades are made of quartz. Variations in breakage patterns also reveal differences between these two subtypes, for 67.56% of the retouched blades are broken at the proximal or bulbar end, whereas 56.38% of the simple microliths are snapped off at the distal end.

Perhaps this can be attributed not only to the types of stone used, but also to distinctive methods of hafting and to the various functions that these implements were meant to serve. For example, crescentic blades, penknives, triangles, points and blunted-back blades may have served as tips and barbs for projectiles such as arrows, spears and harpoons. Simple, parallel-sided bladelets on the other hand could have been multi-purpose tools that were meant to be utilized largely on a living site or in its immediate environs.

Interestingly enough, neither length, breadth or thickness appear to be distinguishing factors between the two types of blades, though the ones on chert tend to be longer and wider by a slender margin of only 1 or 2 mm. This is because the mean dimensions of chert pebbles exceed those of quartz by a few millimetres. The average lengths, breadths and thicknesses of blades in general are 1.6 to 1.4 cm., 0.6 cm. and 0.3 cm. respectively.

4. Moreover, quantitative relationships and distribution patterns indicate that all the lithic components in sites, from blades to cores, flakes and chips, tend to occupy different areas. These different areal frequencies seem to form interrelated patterns which may have been controlled by well-established social traditions that probably continued for a considerable period of time, as indicated by data from test-pits. It is common to find higher concentrations of chips in the parts of sites that overlook or are nearest to watercourses. Pebbles tend to be inversely proportionate to chips, as are blades to cores.

5. On the bases of artifact frequencies, distribution patterns, the varying distances of sites from water, and the differences in the ratios of blades to blade scars on cores, it has been possible to make an arbitrary division of the sampled sites into two groups.

The locales in Group I (CRT-7, CRT-15, RVR-1, RVR-6) are situated between 200 and 980 metres from water and they contain higher percentages of retouched blades, although the simple blades predominate on all the sites. The retouched pieces are scattered in the parts of the sites that are farthest from water, while the blade cores occur at the nearer ends. These sites are characterized by a higher number of chips and a greater use of quartz. Another distinctive feature is that there are more blades than the numbers of blade scars on cores.

In contrast, the assemblages of Group II (RTG-4, CRT-9, CRT-22, TMR-5) are located only 35-110 metres from water, and are exceptionally rich in all types of tools as well as in debitage. This group of sites has yielded most of the scrapers. Moreover, the number of blade scars exceeds that of blades, thereby suggesting that the assemblages concerned not only reflect intensive knapping activities and those associated with the repair and maintenance of tools made of stone and other materials, but also mark the locales that were most convenient for undertaking activities like fishing, hunting, and the collection of plants.

Although it is difficult to ascertain which group of sites was more closely associated with the 'living' activities of a family or a band of people, it appears that the dominant features of these two types of sites are combined in CRT-19 (Cooper 1983), which is one of the largest open-air stations, covering an area of 18,660 sq. m., and overlooking the Chitrakot Falls. Sections 'C' and 'F' on this site are the only areas that are directly accessible to the sandbars in the gorge, and they contain a higher proportion of blade scars in relation to the number of blades. In addition, they provide clear evidence of the transportation of lithic raw material to the site, and the conveyance of the finished artifacts to the gorge. It is also from these two zones that pebbles and nodules were transferred to other areas on the site, especially chosen for the manufacture and use of certain tools. Thus, there is a striking resemblance between the sites of Group II and sections 'C' and 'F' on CRT-19.

On the basis of the occurrence of retouched blades and the marked increase in small chips, the western part of CRT-19 may be compared with the Group I sites, though it is not possible to discern further similarities as the latter exhibit a smaller degree of uniformity in intra-site distribution patterns than do the assemblages of Group II.

It must be noted that the two types of sites recognized so far are not typical of or confined to a particular ecozone, but are scattered throughout the study area. This implies that two sites which may occur close together in one locale but at varying distances from water could differ in terms of frequencies and the distributions of artifacts. However, although such stations may represent different activities, they could nevertheless have served a combined function relating to the exploitation of certain resources as well as to other activities typical of a base camp. In other words, a particular set of opportunities for exploitation is not necessarily associated with just one site but may have entailed the allocation of vital functions to two or more stations within one locale. Therefore, these sites were probably used simultaneously for different purposes, depending upon the resources to be exploited and the time of year.

It is also possible that the ecozones that provided abundant food resources were inhabited for a greater part of the year, while others supported only transient encampments. A tendency towards a greater reliance upon aquatic resources undoubtedly led to increased sedentism and the development of a specialized economy that was best suited to a riverine environment.

The site of CRT-19, which comprises the distinctive aspects of the two groups mentioned above, has a unique location near the waterfall with its diverse food resources. The clusters of smaller stations along the streams, on the other hand, represent an adaptation to a different set of circumstances which required a network of separate but interdependent encampments.

The complex arrangement of sites and their contents suggests the existence of highly efficient subsistence strategies that availed of the rich biomass and made long-term settlement in the region possible. As the sandbars and the major pools in the Indravati river are flooded during the monsoon, and hunting is rendered difficult because of the dense undergrowth, large aggregations of people were probably compelled to break up into smaller groups and take to fishing along the smaller streams with the aid of traps and weirs. Plant foods and edible fungi may have also attracted forays into the forests away from the river. On the whole, therefore, conditions in this area were such that human habitations tended to be concentrated along the watercourses rather than elsewhere. Social organization must have been flexible enough to minimise territoriality and to permit bands to congregate and co-operate with each other with relative freedom.

THE KURUKS

A study of modern Kuruk fishermen, who are a sub-caste of the Maria Gonds, demonstrates the potential of this area to support fairly large groups. The juxtaposition of the prehistoric sites with the houses of the fishermen and the continuation of traditional fishing and collecting methods of extracting food, in spite of the introduction of agriculture, provided an excellent insight into the subsistence strategies which might have been used by the makers of the microliths. The extent to which the dwindling forests still supply the tribal people with building materials, fuel, plant foods, and medicinal plants is indeed remarkable.

An examination of 48 catches from and around the great pool formed by the Chitrakot waterfall revealed not only the diversity of aquatic fauna but the size ranges of various fishes and the wide variety of fishing tackle and gear that are specially adapted to the catching of different species - from small crustaceans to the Rita buchanani that attains a length of well over one metre. In fact, one can observe at least three different methods of fishing being employed here in one afternoon. It is small wonder then that the largest sites are located here and that microliths cover extensive areas at points along streams where weirs are usually built today.

The dry summer months mark the peak of the fishing and hunting season. As most of the large game has now been decimated, hunting with the bow and arrow as well as with sticks and nets is restricted to smaller mammals and birds. The latter, along with fish, constitute the chief sources of protein in the diet of the fisherfolk. And although much of their sustenance is obtained from cultivated grains and cereals, the local population is hardly affected by crop failure as the gorge still preserves some forest cover and thereby offers abundant plant foods. In spite of the fact that the current system of subsistence and the species exploited cannot be expected to be exactly similar to those of the past, it is noteworthy that many foraging techniques practised today in this region are depicted in rock paintings in the caves and shelters around Bhimbetka in Raisen district of Madhya Pradesh (Mathpal 1978). Some of this rock art is ascribed to the Mesolithic and indicates the widespread use of several hunting, fishing and gathering methods that still play an important part in the rural economy, not only in Bastar but in many other regions of the Indian peninsula where the environment is less disturbed by the encroachment of agriculture.

Amongst the Kuruks, sexual differences in the division of labour are not too marked and work tends to be divided according to the physical capacity of an individual. For example, strenuous tasks such as the manufacture and use of large fishing nets and hunting are generally undertaken by young men, though women and children are also permitted to catch fish, albeit the smaller ones. The collection of plant foods is mainly the responsibility of the women. However, during periods when certain plants are available in great abundance, entire families will participate in gathering them.

The Stone Age knappers apparently belonged to a large population unit comprising groups and bands that enjoyed a wide scope for intercommunication and the freedom to migrate and settle in the places of their choice. In due course, as a result of population pressure, the adoption of farming, and the need to exercise territorial rights, the freedom of movement was curtailed and the opportunities for intermixture among groups gradually decreased. The Kuruks can no doubt trace some of their ancestry to these early settlers, though a direct line of descent cannot be established because of the fluid structure of society that has prevailed in the past and which has allowed a continuance of local migrations until fairly recently.

REFERENCES

Cooper, Z.M. 1983. CRT-19: A Mesolithic site in Bastar District (M.P.). Man and Environment. 7:1-30.

Jacobson, J. 1980. Investigations of Late Stone Age cultural adaptations in the Central Vindhyas. Man and Environment. 4:65-82.

Joshi, R.V. 1978. Stone Age cultures of Central India. Deccan College Postgraduate and Research Institute, Pune.

Mathpal, Y. 1978. Prehistoric rock paintings of Bhimbetka, Central India. Unpublished Ph.D. Thesis, Poona University.

Misra, V.N. 1973. Bagor - A Late Mesolithic settlement in north-west India. World Archaeology. 5(1):92-110.

Misra, V.N., Y. Mathpal, and M. Nagar. 1977. Bhimbetka: Prehistoric man and his art in Central India. Deccan College, Pune.

Murty, M.L.K. 1981. Hunter-gatherer ecosystems and archaeological patterns of subsistence behaviour on the south-east coast of India: an ethnographical model. World Archaeology. 13(1):47-58.

Sharma, G.R. 1973. Mesolithic lake cultures in the Ganga Valley, India. Proceedings of the Prehistoric Society. 39:129-146.

Sharma, G.R., V.D. Misra, and J.N. Pal. 1980. Excavations at Mahadaha: 1977-78. Allahabad University, Allahabad.

PALAEOLITHIC CULTURES AND ETHNOGRAPHY OF THE GUNJANA VALLEY, ANDHRA PRADESH

D.R. Raju
Deccan College, Pune

This paper summarizes investigations on Palaeolithic sites and ethnography in the Gunjana valley, Cuddapah district, carried out between 1976 and 1980. The research formed the basis for my Ph.D. dissertation submitted to Poona University (Raju 1981). Cuddapah district of Southern Andhra Pradesh covers an area of about 15,000 sq. km. It is encircled by the Nallamalai hill ranges to the north, the Palakondas to the south, the Velikondas to the east, and the Erramalais to the west. The district is drained by the rivers Penneru, Papaghni, Cheyyeru and Sagileru and their tributaries (see Fig. 1). The forests of the region are dry deciduous and tropical thorny in nature, and the mean annual rainfall is 750 mm.

My investigations were confined to an intensive exploration of the valley of the river Gunjana, a tributary of the river Cheyyuru in Rajampet taluka of Cuddapah district (see Fig. 2). Previous archaeological investigations (Reddy 1968) in the Cuddapah district had produced stone tool assemblages of four Stone Age periods (see Fig. 1) - Lower Palaeolithic (44 sites), Middle Palaeolithic (20 sites), Upper Palaeolithic (only 1 site), and Mesolithic (4 sites). The evidence for the Upper Palaeolithic was thus scanty. The raw materials used for these assemblages were a coarse to medium-grained quartzite for the Lower Palaeolithic, a fine grained quartzite for the Middle Palaeolithic, and silicious cryptocrystalline rocks like chert, jasper and quartz for the later industries.

My explorations in the Gunjana valley, over an area of about 2,000 sq. km., have brought to light 10 Acheulian, 2 Middle Palaeolithic, and 10 Upper Palaeolithic sites. Lithic artefacts were collected for analysis from a total of 12 sites (see Table 1). An excavation was also carried out at Vodikalu, one of the Upper Palaeolithic habitation sites which has an undisturbed primary occupation deposit.

The Acheulian sites are situated along ephemeral streams and braided runnels 1 to 2 km. away from the main river in a scrub and thorny thicket ecosystem. The Acheulian tool kit consists mainly of handaxes and cleavers, the latter occurring in smaller numbers. The raw material is a coarse to medium-grained quartzite abundantly available in the Cuddapah formations. The tools were bifacially worked by a cylinder hammer technique, and have symmetrical outlines, straight profiles, and biconvex to lenticular cross-sections. The handaxes have an average of 24 flake scars per tool, and the majority are of an ovate shape. Some of the handaxes

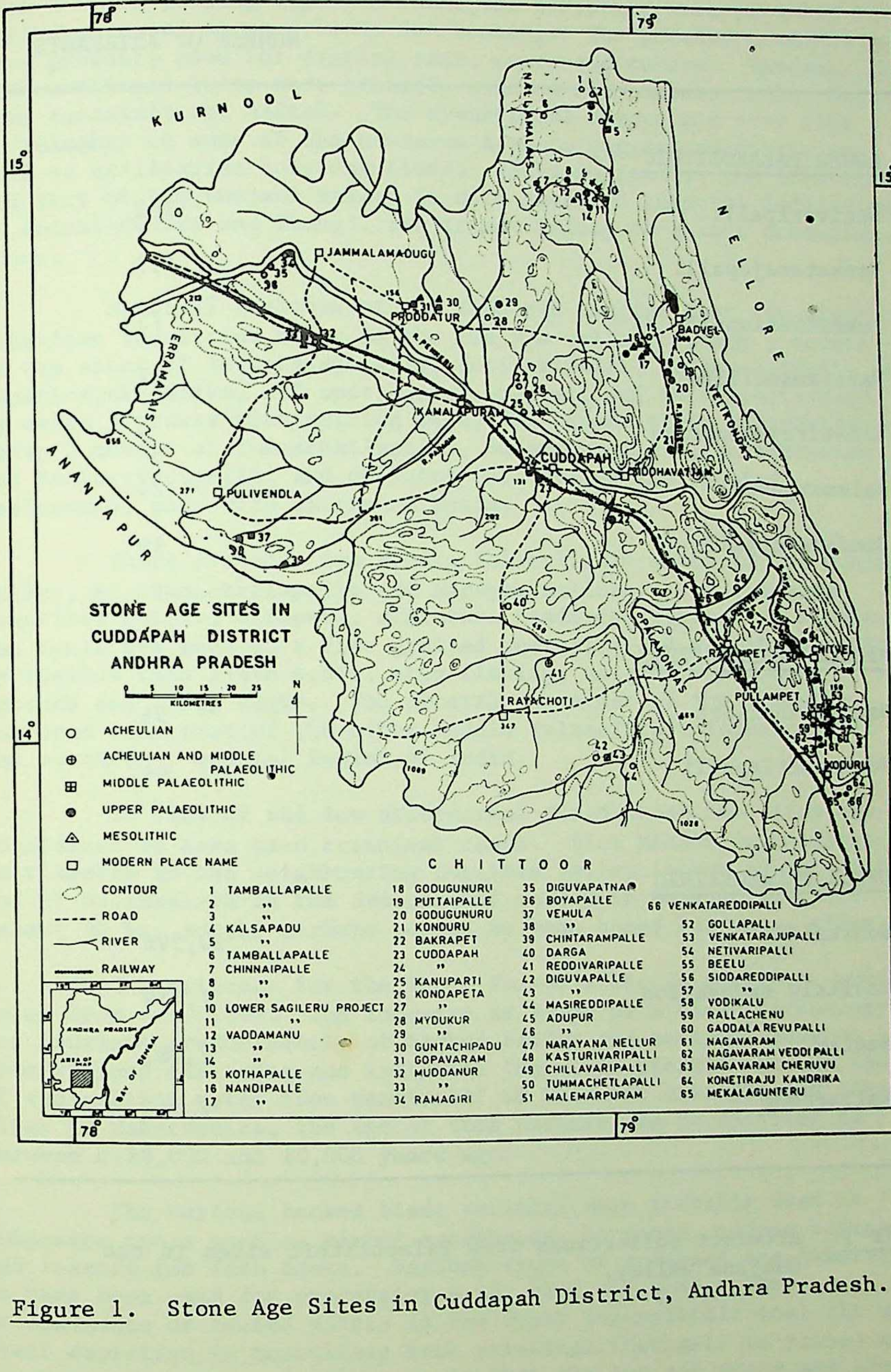

Figure 1. Stone Age Sites in Cuddapah District, Andhra Pradesh.

	NUMBER OF ARTEFACTS
LOWER PALAEOLITHIC	
Netivaripalli	162
Venkatarajupalli	119
Tummachetlapalli	73
Narayananellore	47
Konetirajukandrika	9
Malemarpuram	24
Siddareddipalli	19
MIDDLE PALAEOLITHIC	
Narayananellore	94
Tummachetlapalli	44
UPPER PALAEOLITHIC	
Vodikalu	10,596
Vodikalu excavation	1,439
Beellu	2,183
Rallachenu	2,046

Table 1. Artefact collections from Palaeolithic sites in the Gunjana valley.

with a sharp cutting edge all round the periphery were probably hafted and used as spearheads for hunting. The pointed handaxes were probably used for digging yams, roots and tubers. Handaxes with untrimmed butts were probably used as all-purpose tools, but were certainly not hafted. The symmetrical shapes and very fine workmanship on some of the handaxes seem to suggest aesthetic as well as utilitarian considerations. Technologically, the Acheulian industry of the Gunjana valley is more advanced than the industries of Chirki-Nevasa and Hunsgi, and it may belong to a late Acheulian phase.

Metrical analyses of the handaxes suggest that two distinct Acheulian industries occur in the Gunjana valley. Group 1 occurs at the sites of Venkatarajupalli, Netivaripalli, Siddareddipalli and Konetirajukandrika, all upstream of Chitvel, and is characterized by ovate handaxes with cutting edges all around their peripheries. Group 2 occurs at Tummachetlapalli, Narayananellore, Malemarpuram and Kasturivaripalli, and contains both ovates and pointed implements, many with untrimmed butts.

There are only two Middle Palaeolithic sites in the Gunjana valley, at Tummachetlapalli and Narayananellore. The industry comprises points, scrapers, miniature handaxes, flakes and blades. The tools are made on a fine grained quartzite and are characterized by shallow thin flake scars, step flaking, marginal secondary retouch and sharp edges. The general character of the industry conforms with that of the other Middle Palaeolithic industries of the south-east coastal region of India.

In view of the low artefactual yield these two sites are considered to have been transient camps. Rich Middle Palaeolithic settlements in the neighbouring Sagileru valley (about 60 km. north) and at Rallakalava in the Swarnamukhi valley in Chittor district (about 50 km. south) perhaps served as home bases for these sites.

The evidence for the Upper Palaeolithic is prolific, and comes from ten sites. The industry is based on a blade technology, and consists predominantly of backed blades and scrapers made on fine-grained quartzite and lydianite (Raju, in press). On the basis of radiocarbon dates from Nandipalli in Cuddapah district and other sites in Maharashtra, the age of this culture can be ascribed to between c.20,000 and 10,000 years ago.

The various backed blade variants were probably used in composite tools such as barbed arrowheads, harpoons, slicer knives, and inserts for fish hooks. Various types of scrapers are likely to have been used for processing wood, hide and bone. The predominance of backed points in the Upper Palaeolithic tool kit and their depiction in Mesolithic rock paintings (Mathpal, in press) as elements of arrows and spears imply that the bow and arrow and the spear were the principal hunting weapons.

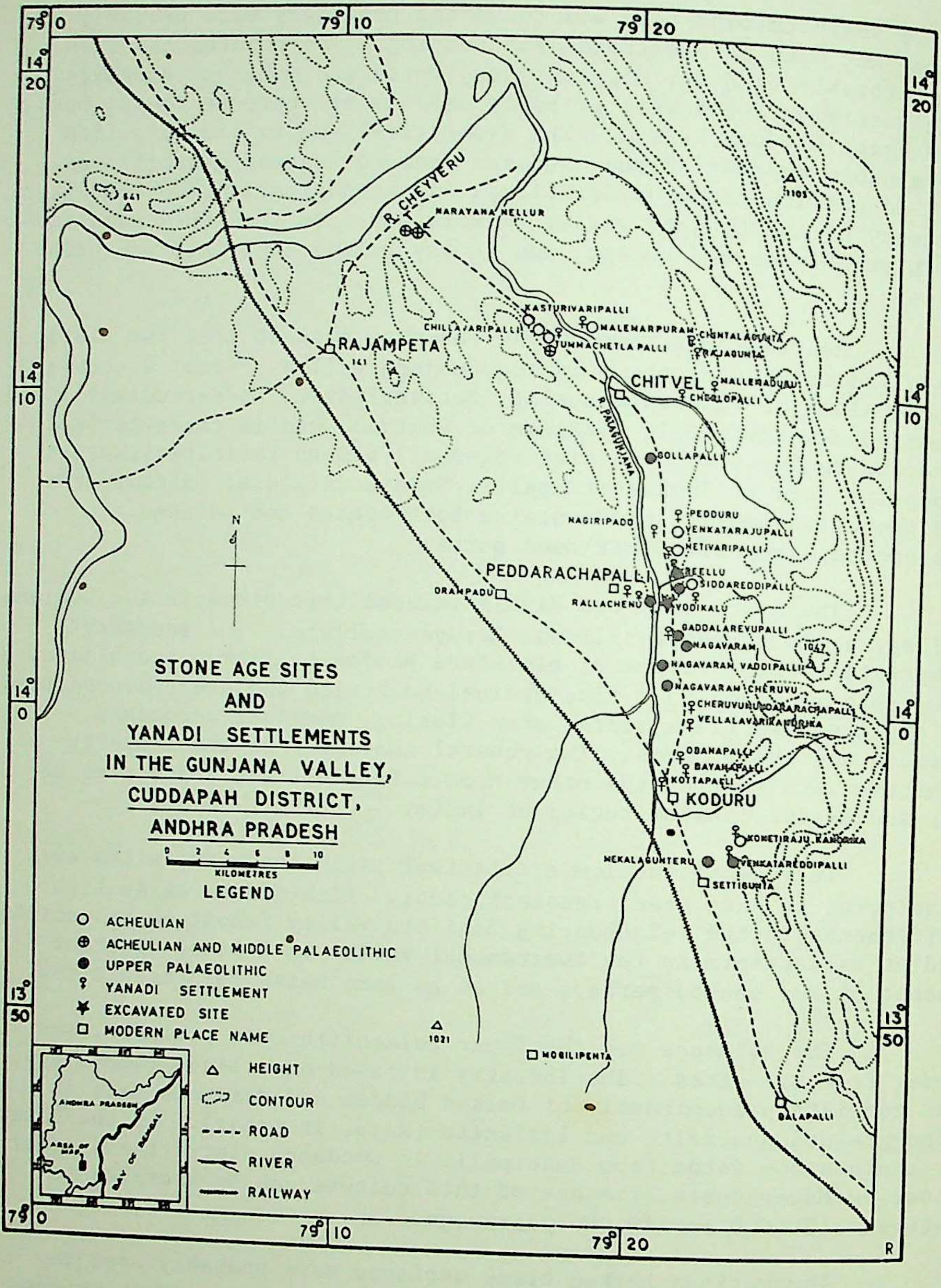

Figure 2. Stone Age Sites and Yanadi Settlements.

The trial excavation at Vodikalu revealed that the archaeological horizon was covered by a fine alluvial loam deposited by a sluggish stream. This covered the cultural materials, which lay exposed on the adjacent land surface, without transporting them. The excavation yielded, along with flaked artefacts, 84 pieces of flat grinding stone slabs, 19 rubbers and 135 split pebbles, all suggesting the processing of vegetable foods on the site. This evidence conforms with that found in surface contexts at Renigunta. These objects provide further evidence that the Mesolithic traditions in which they became more common were rooted in the preceding local Upper Palaeolithic.

The spatial distributions of the artefacts within the site point to specific activity loci, although in the absence of biological remains it is difficult to be precise about the nature of the activities performed. However, the functional attributes of the lithic artefacts suggest that woodworking, hunting, butchering, skinning, and fishing activities were carried out.

Further, the extensive distributions of the artefacts at Vodikallu, Beellu and Rallachenu (up to 3 km. in length) and their high densities (5 to 60 per sq. m.) suggest that these sites may have served as home bases. They are located on alluvial flats overlooking perennial pools in the Gunjana river. This relationship strongly suggests the exploitation of aquatic resources. Moreover, the locations of these sites are such that they never become inundated, even when the Gunjana is at the peak of its monsoonal spate. Also, the absences of base camps in the foothills or interior forests may suggest that these alluvial sites were all-season camps with prolonged occupations.

An analysis of the distribution of the Upper Palaeolithic settlements suggests that at least two served as home bases. These were Venkatareddipalli (with a transient camp at Mekala-gunteru), and Vodikalu. Additional base camps probably existed at Gaddalarevupalli, Nagavaram, Rallachenu and Beellu, and transient camps at Nagavaram Cheruvu, Nagavaram Voddipalli, and Gollapalli. All these camps are well-located with respect to critical resources like water, raw materials for tools, and food.

An attempt to estimate the populations of Vodikalu and neighbouring camps, based on approximate floor areas and the settlement patterns of documented ethnographic populations, suggests that Vodikalu could have supported 190 people divided into six minimum bands, each comprising 5 or 6 nuclear families of 5 members each. Beellu could have supported two minimum bands of six nuclear families each (a total of about 60 people), and Rallachenu could have supported about 30 people - one minimum band with 6 nuclear families. These figures, however, are by their very nature highly speculative.

THE YANADIS

A study of the way of life of the Yanadi fisher and hunter-gatherer people who inhabit the Gunjana valley today, very often living on the same sites as were occupied by Upper Palaeolithic people, was undertaken with a view to gain an insight into the subsistence and settlement patterns of the Upper Palaeolithic. The Yanadis were until recently pure hunter-gatherers, but now many groups have settled near farming villages where they work as manual labourers or watchmen in the fields of agriculturalists. Traditionally, they lived in bands of 3 to 20 families in rather haphazard settlements of circular huts with conical roofs, made entirely of plant materials. Such huts are still built and are generally 3 to 4 m. in diameter with walls 0.5 to 1.5 m. in height. Entrances are very small (0.95 to 1.10 m. high; 0.70 to 0.95 m. wide) and are closed by doors of leaves and twigs.

The Yanadis have an expert knowledge of their environment. They are intimately familiar with all animals, birds, fish and useful plants in their habitat, and these play important roles in subsistence. Yanadi hunting expeditions consist of 3 to 10 persons, who traverse the forest for up to 20 km. and stay away from their settlements for 3 to 4 days, or even up to 10 days if game is scarce. They erect small temporary huts for shelter in the forest or use caves and rock-shelters when available. After a kill is made, a portion of it is cooked and eaten on the spot, and the rest is sun-dried on rocks and taken back home for later use, together with bones, horns and antlers required for other purposes. Quartz and quartzite flakes are often used for butchering.

The Yanadis hunt at least 14 species of terrestrial game with snares, nets and other methods. The prey includes hares, lizards, squirrels, porcupines, wildcats, rats, bandicoots and langur monkeys. They also catch at least 45 species of fresh water fish by as many as 12 different methods, using fish-traps, weirs, nets, hooks and poisons.

In addition, they can identify 68 species of birds, of which 6 are regularly caught in nets, snares and cages. They consume at least 13 species of yams, wild roots and tubers, 10 leafy greens, and 25 species of edible fruits. They collect 22 other items of minor forest produce, and after using some of these for subsistence they exchange the rest with farmers for grain or cash.

It is interesting to note that the various local names for species in the flora and fauna, and many of their food and medicinal uses, are known only to the Yanadis and not to any of the fully agricultural communities in the region. Their intimate knowledge suggests a long tradition of extensive exploitation. The physical correspondences between the locations of Upper Palaeolithic and

Yanadi settlements are too close to be purely coincidental. Indeed, it seems very likely that the Yanadis are the cultural and biological descendants of the Stone Age hunter-gatherers of the region, who probably lived a lifestyle not very different in terms of the nature of their settlements and their subsistence patterns.

ACKNOWLEDGEMENTS

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REFERENCES

Mathpal, Y. In press. The hunter-gatherer way of life depicted in the Mesolithic rock-paintings of Central India. In Recent advances in Indo-Pacific prehistory (eds V.N. Misra and P.S. Bellwood). Oxford and IBH, New Delhi.

Raju, D.R. In press. The Upper Palaeolithic industries of Cuddapah District, Andhra Pradesh. In Recent advances in Indo-Pacific prehistory (eds V.N. Misra and P.S. Bellwood). Oxford and IBH, New Delhi.

---------- 1981. Early Settlement Patterns in Cuddapah District, Andhra-Pradesh. Unpublished Ph.D. dissertation, Poona University.

Reddy, K.T. 1968. The Prehistory of Cuddapah. Unpublished Ph.D. dissertation, Poona University.

THE COASTAL MESOLITHIC INDUSTRIES OF SOUTH INDIA AND THEIR CHRONOLOGY

P. Rajendran
Deccan College, Pune

INTRODUCTION

Prehistoric studies since 1974 in various parts of Kerala, the south-eastern coast of Tamil Nadu and coastal Karnataka have yielded similar types of material culture from the Mesolithic period, in geomorphic contexts which indicate an early Holocene date. These coastal Mesolithic industries of southern India differ in their typo-technological and morphological features from those of northern India, which are made primarily on small blades. The industries of the southern coastal region are made mainly on flakes. They consist of large implements, and the general characteristics do not justify usage of the term 'microlithic'. Based on my recent studies an attempt is made here to present a comprehensive picture of the Mesolithic industries of these coastal regions and their probable chronology.

Southern India, especially its coastal regions, has been previously little considered in prehistoric studies. Except for a few sites in the Tinnevelli district of southern Tamil Nadu and a solitary site at Chevayur near Calicut in north Kerala, no Mesolithic industries were known until recently (Rajendran 1979). In terms of Palaeolithic sites Kerala remained a total blank until 1973, and it was even suggested that this part of India was uninhabited by prehistoric groups due to unsuitable environmental factors such as heavy rainfall, impenetrable forests, highly dissected terrain, and an absence of suitable raw materials such as quartzite.

However, Kerala today enjoys one of the richest natural settings in southern India, if not in the whole country. Physiographically it has three distinct zones: lowlands, midlands and highlands. The lowlands lie near the coast below 15 m. altitude and consist of sub-recent to recent deposits, with high lateritic headlands in some places. The midlands consist of various types of laterite at different levels, which range from Tertiary to Pleistocene in age. The highlands include the hill region and its foot-hills, and they retain the evergreen forests which still support rich floras and faunas.

The region has several perennial rivers, and also the north-south alignments of back-waters (Kayalas) in the lowlands. Most rivers of the region flow westwards through narrow and steep valleys. The majority empty into the back-waters, and a few have direct courses into the Arabian Sea. Climatically, Kerala is

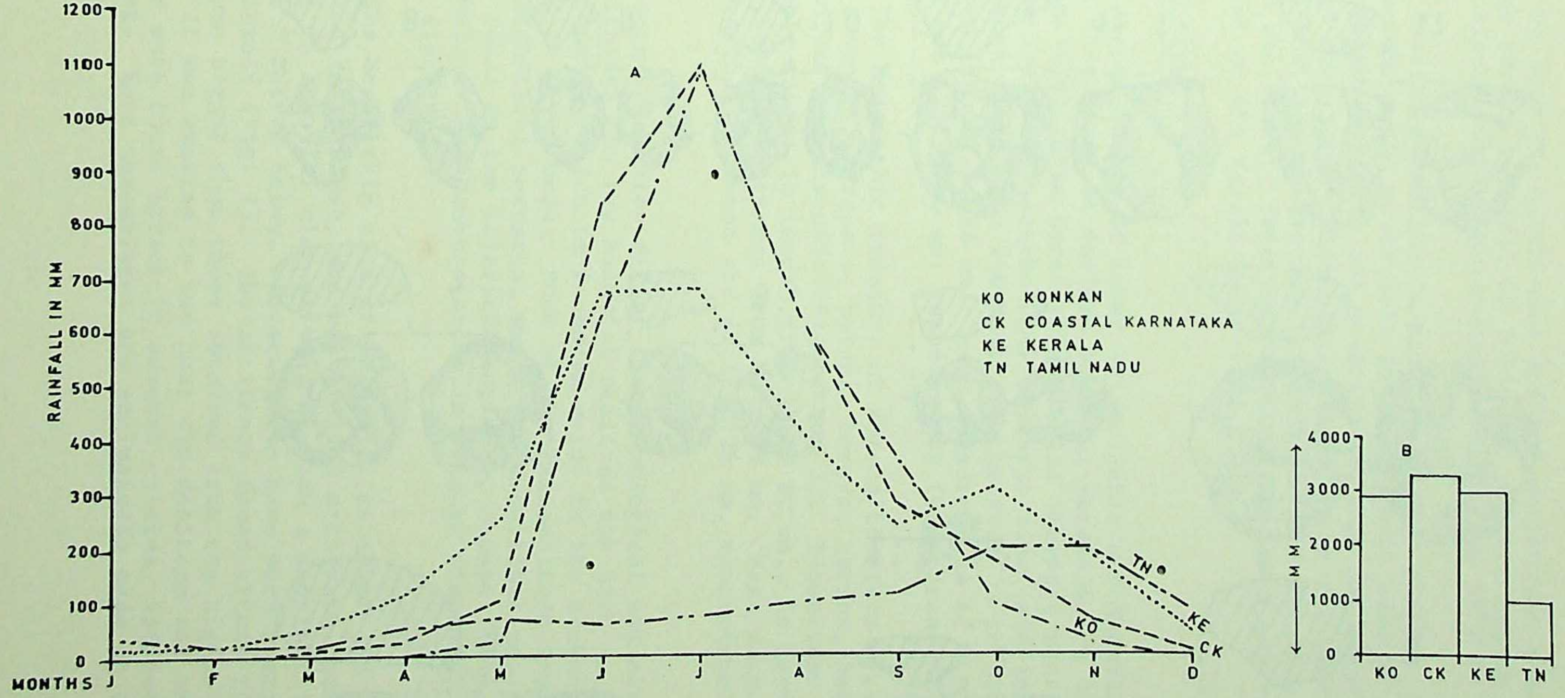


Figure 1. Average Rainfall on the Southwest and Southeast Coasts of India.

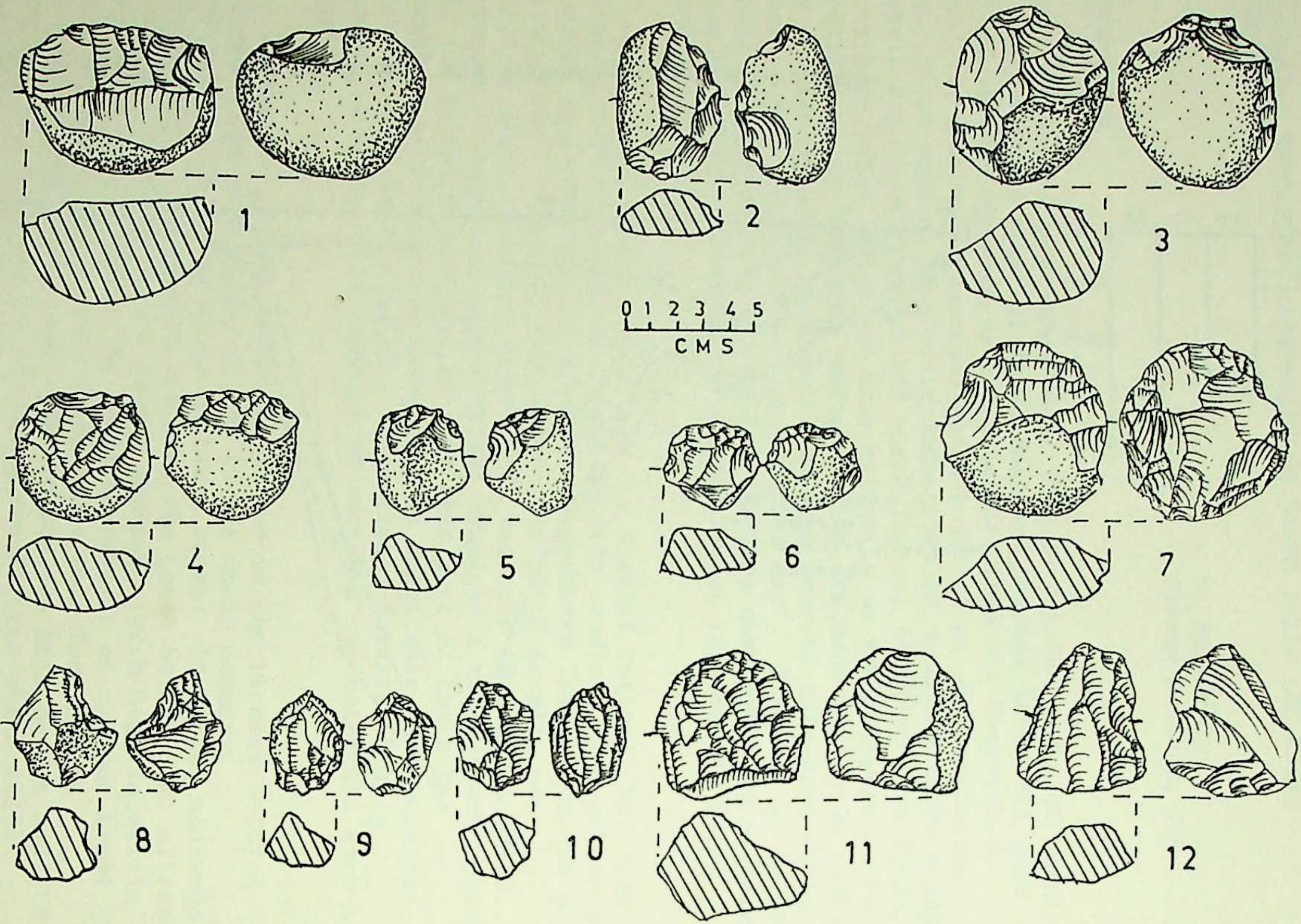


Figure 2. Malampuzha Mesolithic Artifacts, Kerala.

favoured by both the south-west and the north-east monsoons. It has an average annual rainfall of 3085 mm., and the region enjoys an equable climate with temperatures varying from 69°F to 99°F.

Coastal Karnataka is environmentally similar to Kerala, but the situation on the south-east coast of Tamil Nadu is different. In physiography, climate and vegetation these two coastal regions show great contrasts. Tinnevelli district, on the south-east coast of Tamil Nadu, has an average rainfall of only 810 mm., which is the lowest in the State. This region therefore has a semi-arid climate, unlike that on the Kerala coast (Fig. 1).

STONE AGE SITES

A good number of Lower Palaeolithic and Mesolithic sites have been discovered in various parts of Kerala since 1974 (Rajendran 1979). The Lower Palaeolithic industry consists of chopper-scraper-flake assemblages of large size, and implement lengths range from 58 to 200 mm., breaths from 52 to 128 mm., and thicknesses from 31 to 88 mm. Mean measurements of length/breadth/thickness are 129/90/60 mm. respectively (Rajendran 1981).

The Mesolithic industry of Kerala consists of various types of small choppers, scrapers, points, borers, burins, lunates, blades, knives and discoids (Figs 2 and 3). Dimensions show a considerable range; in length from 15 to 80 mm., in breadth from 6 to 74 mm., and in thickness from 4 to 48 mm. Mean measurements of length/breadth/ thickness are 47.5/40/26 mm. respectively (Rajendran 1978).

Both industries differ in technological and morphological aspects although the raw material utilized for both is the locally-available quartz, which is found as veins in the Archaean gneiss and as pebbles in river beds. Most of the Palaeolithic implements are found on high-level terraces, while the Mesolithic artifacts are generally found on the lateritic surfaces, except those obtained from the Walayar and Mankara sites in Palghat district, and Tenmalai in Quilon district.

The Mesolithic site at Walayar lies about 183 m. above sea-level in the Palghat Gap, and has yielded artifacts both from the surface of an alluvial clay as well as from a detrital laterite which lies 2 metres below. No artifacts have been found within the alluvium itself (Fig. 4). The artifacts found within the detrital laterite are bigger than those obtained from the higher alluvial surface. It was amazing to see that the debitage and implements on the latter were found intact in several circles, indicating working on the spot. Both assemblages are exclusively made on quartz.

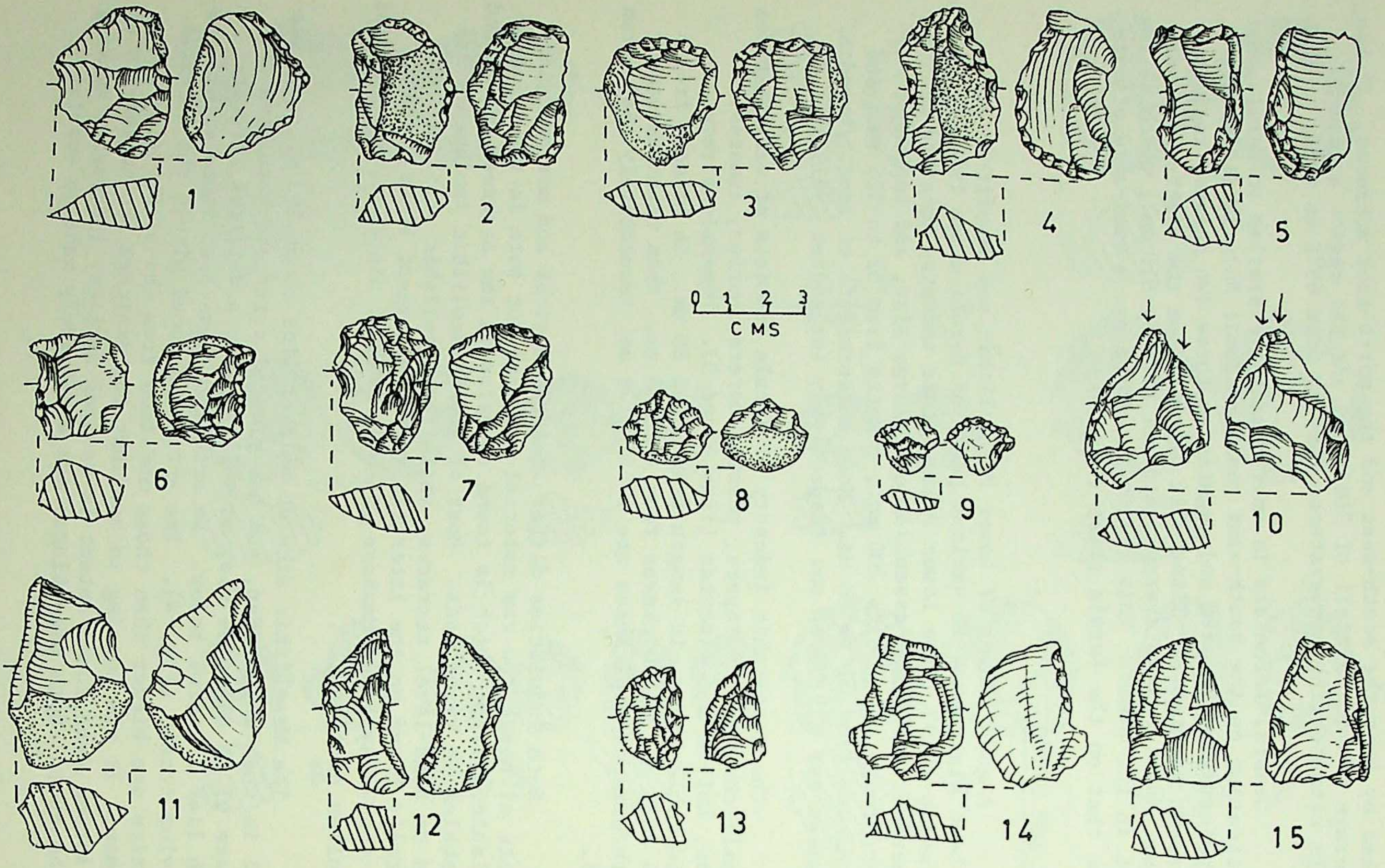


Figure 3. Podippara Mesolithic Artifacts, Kerala.

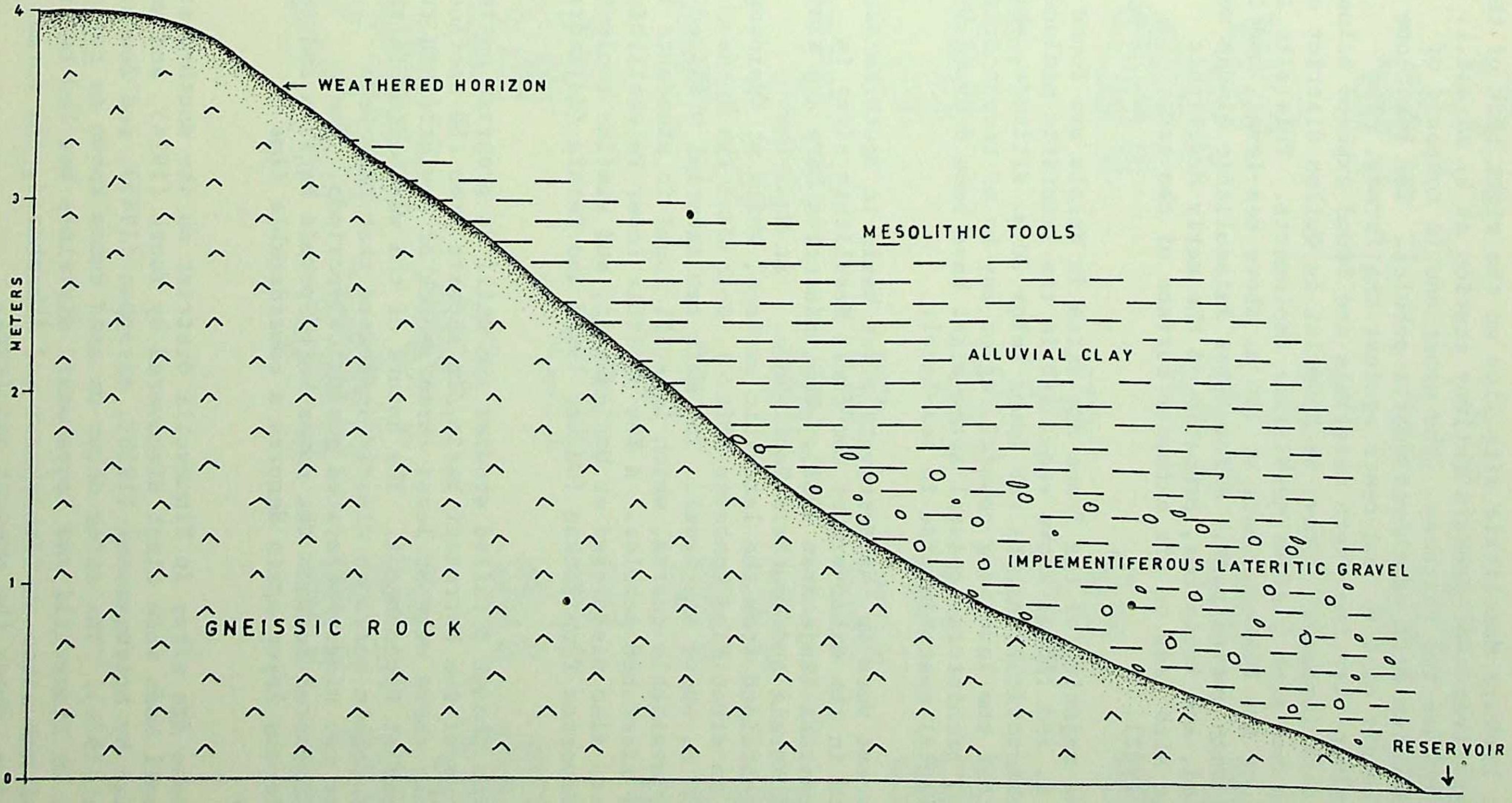


Figure 4. Stratified Mesolithic Site at Walayar, Palghat District, Kerala.

The Mankara Mesolithic site lies on the right bank of the Bharathapuzha river near Mankara railway station at 61 m. a.s.l. Here the river has two terraces. The upper one is composed of lateritic alluvium with weathered quartz pebbles. The lower one has an average height of 2 m. and rests against the former. The implements along with the waste materials are found exposed below this sub-recent terrace. A cave at Tenmalai in Quilon district of South Kerala has also yielded Mesolithic implements. This site lies at the foot of the Western Ghats at 150 m. above sea-level, and is formed in a huge gneiss rock. A few Upper Palaeolithic blades were also obtained, and incisions, probably of the early Mesolithic period, were also seen on the exterior surface of the cave (Rajendran 1982).

The majority of the Stone Age sites in Kerala are found between 30 m. and 180 m. above sea-level in the lateritic midland region. Prehistoric sites are not found below 30 m. altitude, which indicates that the low-lying coastal region may be of recent origin. In addition, prehistoric coastal sites might have been drowned by the post-glacial eustatic rise in sea-level.

Recent work in the Netravati river basin in South Kanara has resulted in the discovery of the first Mesolithic sites in coastal Karnataka (Rajendran 1981). The industries here are similar to those of Kerala and southern Tamil Nadu. At Mani the tools were obtained from the lateritic surface, while at Uppinangadi they occur in stratified contexts (Fig 5). Both sites lie in the midland region at 30 m. above sea-level. The main raw material utilized is the locally-available quartz, which is still found in abundance in the form of river bed pebbles. A few possible Lower Palaeolithic choppers were also discovered at Uppinangadi, and similar tools have also been reported from Konkan (Guzder 1980) and Kerala (Rajendran 1981).

Even though detailed studies are still in progress on the geomorphology of the Netravati basin, it appears from the section (Fig. 6) that there were at least three phases of deviation in the river courses at Uppinangadi. The nature of the weathering in the two earlier pebble horizons clearly indicates that they were deposited at two widely separated geological periods. The disconformity noted between the unweathered pebble horizon and the implementiferous layer again denotes a considerable time difference.

Stone Age sites in Tinnevelli district on the south-eastern coast of Tamil Nadu were first discovered by Foote (1914), and were later studied by Krishnaswami (1938), Aiyappan (1945), and Zeuner and Allchin (1956). The sites occur on sand dunes known as teris. Recent work in Tinnevelli and Kanyakumari districts has led to the discovery of new sites at Idindakarai and Athankarai, the former being only 4 m. above the present sea-level.

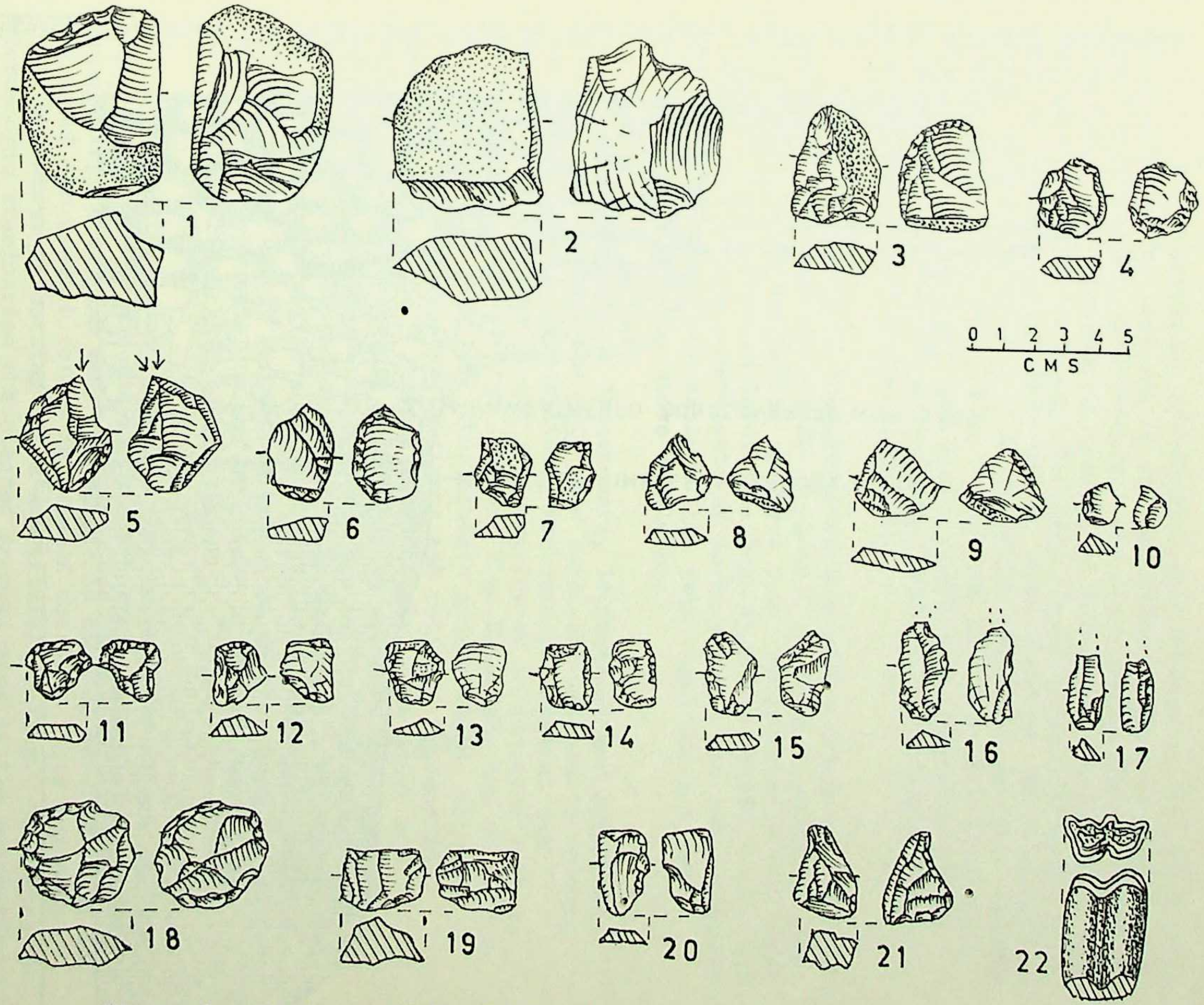
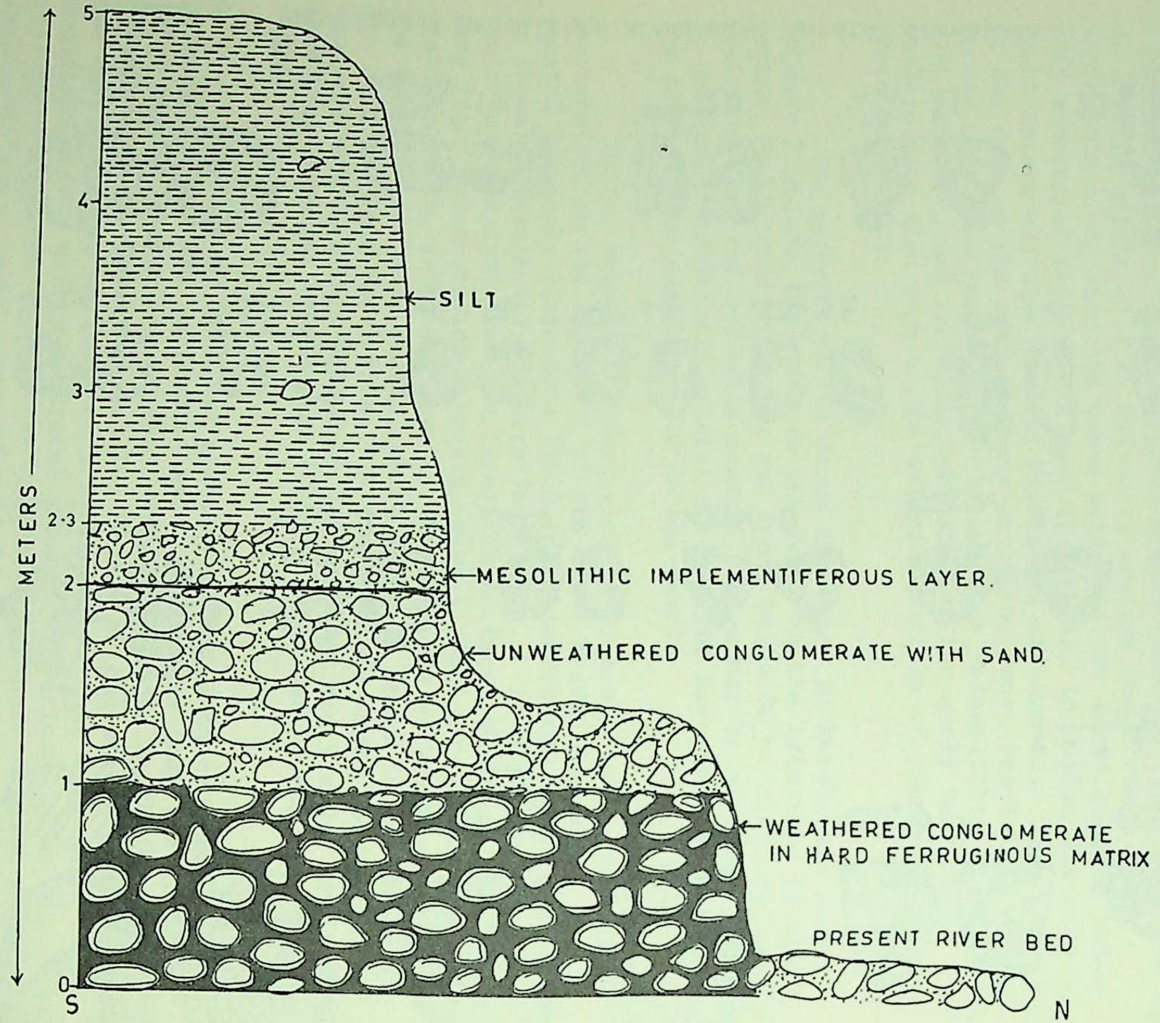


Figure 5. Uppinangadi Mesolithic Artifacts, Coastal Karnataka.


METERS
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UNWEATHERED CONGLOMERATE WITH SAND.
WEATHERED CONGLOMERATE IN HARD FERRUGINOUS MATRIX
PRESENT RIVER BED

Figure 6. Stratified Mesolithic Site at Uppinangadi, South Kanara, Coastal Karnataka.

At Sawyerpuram, Idindakarai and Athankarai the tools are found only on the surfaces of the stabilized *teri* sand dunes, and trial trenches dug at Idindakarai and Sawyerpuram confirm this situation. The sequence of geological formations observed at Idindakarai comprises a late Tertiary limestone at the base, and this is overlain by a beach rock at about 2 metres above high tide level. This is rich in land snails which have been dated to between 20,000 ± 395 years B.P. (B.S. - 134) and 33,670 ± 1640 years B.P. (B.S. - 133). The *teri* sand dunes, which have uniform physical characteristics throughout their thicknesses, rest disconformably over the land snail horizon (Fig. 7).

To the west of the Kanyakumari temple a beach rock is found resting on pre-Cambrian gneiss at about 2 m. above sea-level, and it grades into an aeolianite at about 7 m. Marine shells collected here from 6 m. above sea-level have been dated to 29,890 ± 955 (B.S. - 132). Land snails predominate at 10 m. a.s.l., and reddish-brown sand dunes rest disconformably on the land snail horizon and continue to 15 to 20 m. above sea-level.

Observations at Kanyakumari, Idindakarai and Athankarai clearly indicate that the *teri* sand dunes are uniform in colour, texture and mineral composition. Mechanical, chemical and mineralogical studies on two *teri* samples of well-sorted fine to medium sand, collected from 2 m. and 8 m. below the top of a 10 m. cliff at Muttam, show that they contain quartz (80%), felspar, ilmenite, magnetite, garnet, zircon and rutile. Fe$_2$ and Fe$_3$ contents are 0.2 and 4 percent respectively. The sands are uniformly reddish-brown in colour and do not show any apparent pedogenesis. The colour is probably due to the release of iron oxide from dark-coloured minerals in an oxidising environment, but the uniform pigmentation down to a depth of 10 metres is still a problem. However, it is certain that this uniform colouration is not due to pedogenesis, as was suggested by Zeuner and Allchin (Joshi, Rajaguru and Rajendran 1981).

When *teri* sand is boiled in a solution of dilute HCl and SnCl$_2$ for nearly 10 minutes the reddish-brown colour of the sand becomes separated, and when the sample is cleaned several times in tap water the reddish colour is removed totally. This indicates that the colour is nothing but a superficial coating. Moreover, on microscopic examination the cleaned samples show little weathering of quartz grains or other minerals, and it seems that weathering alone cannot explain the uniform colouration, and the reason for it still remains obscure.

Field observations show that there are at least two strandlines (at 20 and 4-6 m. a.s.l.) found between 8 and 10 km. inland from the present Tamil Nadu coast. However, no evidence could be obtained to substantiate the sea-level changes postulated

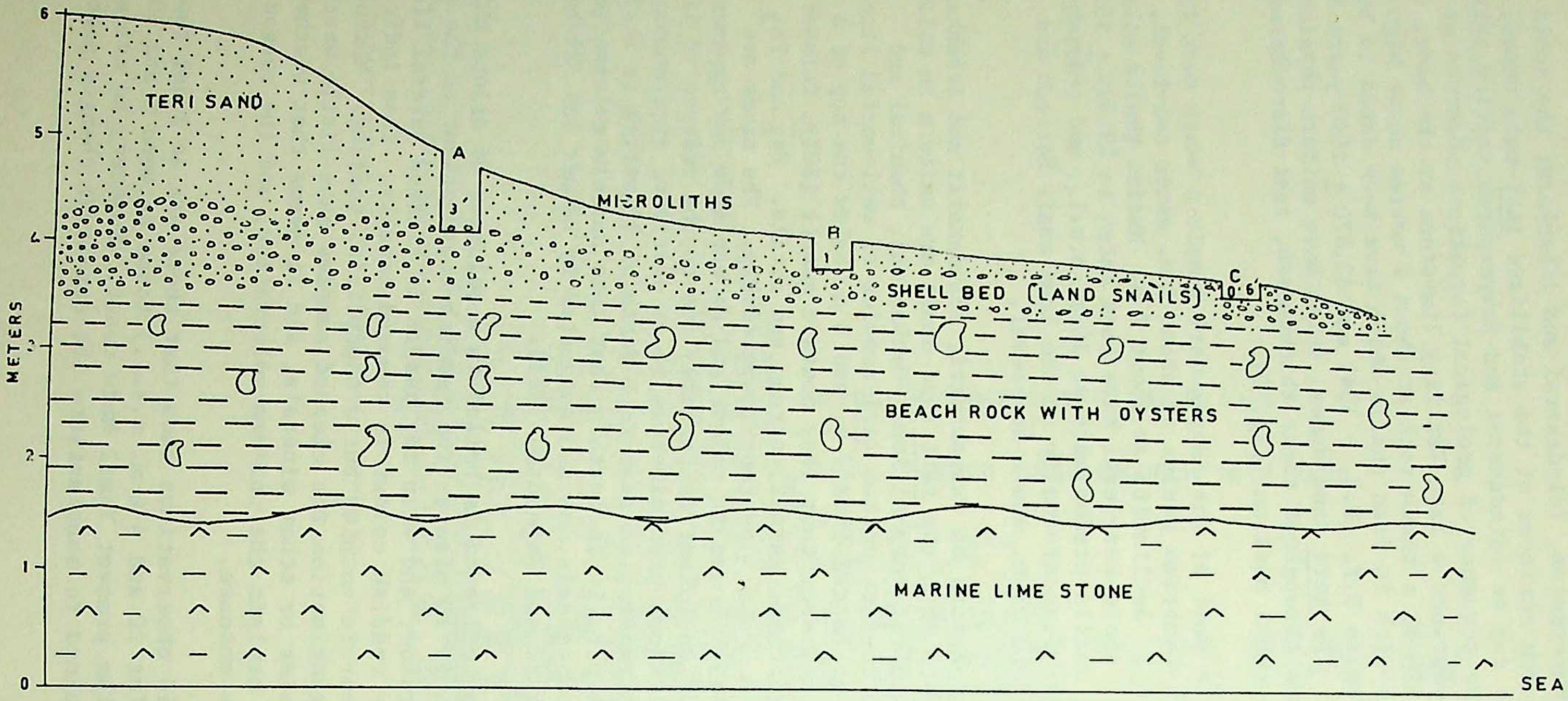

Figure 7. The Section at Idindakarai Showing the Relationship of the Beach Rock and Teris, Tinnevelli District, South Tamilnadu.

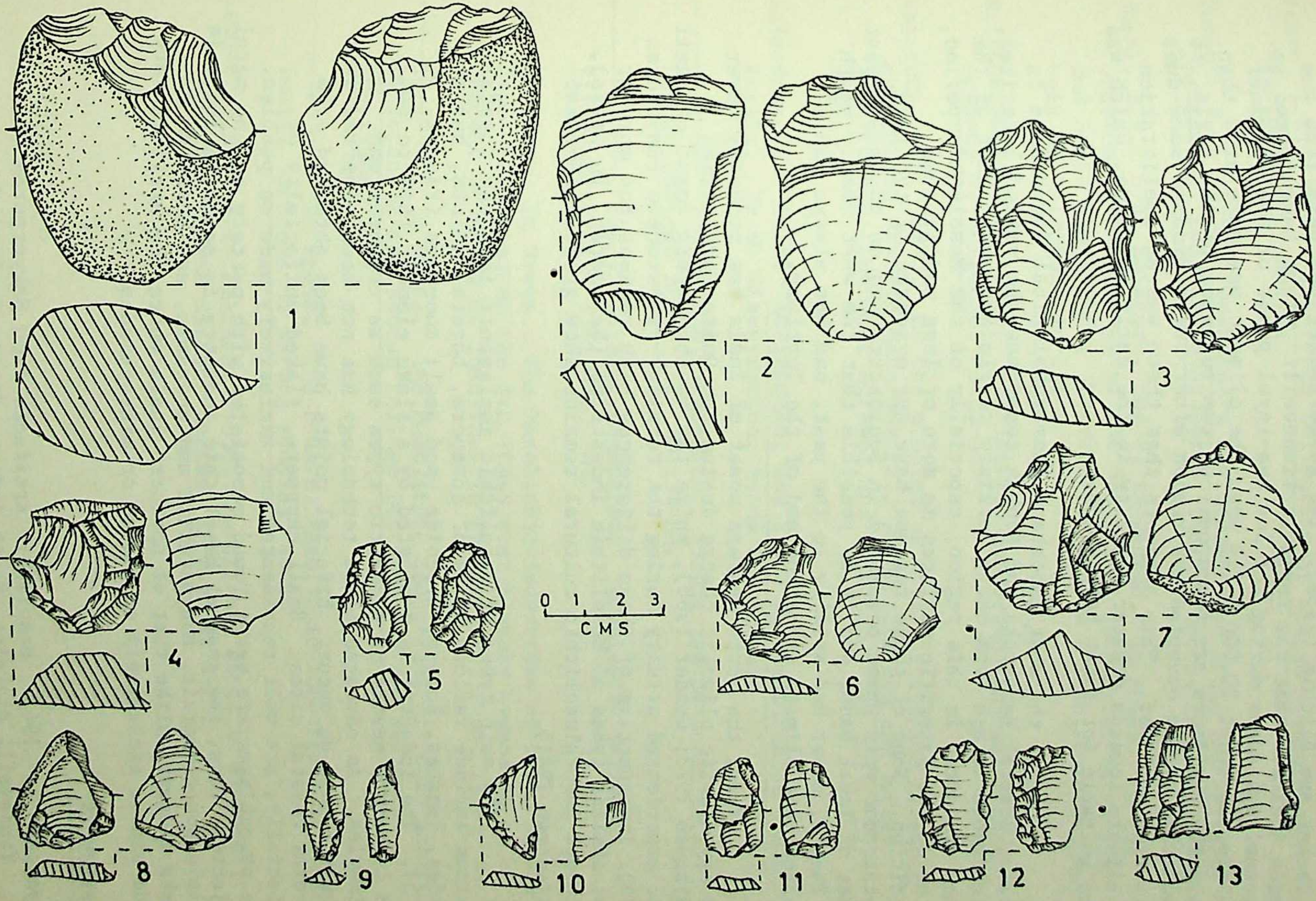

Figure 8. Sawyerpuram Mesolithic Artifacts, South Tamilnadu.

by Zeuner and Allchin (1956). The geomorphological data from the region indicate that the teris in Tinnevelli might have formed as regressional dunes during the low sea-level phase of the terminal Pleistocene (post 20,000 B.P.) when the climate was more arid than now. The artifacts are found only on the surfaces of the teris, so Mesolithic groups occupied the region after the period of sand dune formation was over. This suggests that there was an amelioration of climate towards greater humidity in the early Holocene, which was more suitable for human habitation.

One of the most important geomorphological formations in Kerala, coastal Karnataka and Konkan comprises the varied laterites, which range in age from early Tertiary to Pleistocene. Most of the Stone Age sites in this region, especially of the Mesolithic period, occur on the lateritic surfaces in more or less undisturbed condition. None of these regions have any evidence of the late Pleistocene arid phase evidenced in Saurashtra and on the south-east coast of Tamil Nadu, and it is possible that the west coast, south of Thapti, never had aridity in the past, and has always had a tropical wet climate since the end of the Tertiary.

Thus, the south-western coast of India has probably never had any drastic climatic change during the Quaternary period (Rajaguru 1973; Guzder 1980), while the south-eastern coast of Tamil Nadu experienced aridity during the terminal Pleistocene (Rajendran 1979). Irrespective of these differences both regions had more or less similar types of Mesolithic industries (Rajendran, in press), although the Palaeolithic cultural remains show greater contrast (Rajendran 1981).

The main types of Mesolithic implements in these coastal regions include various types of scrapers, borers, points, burins, blades, lunates, knives, discoids, and small choppers (Figs 2, 3, 5, 8). The industry is dominated by a flake element (60% to 80%), and is mainly devoid of geometric types such as trapezes and triangles. An advanced blade technology has not been observed even though blades do occur. Bifacial points have been obtained from several coastal sites. Small choppers, flaked unifacially or bifacially, are well represented and exclusively made on pebbles. The assemblages are never found associated with pottery or any metal objects. Thus, the coastal Mesolithic industry in southern India is mainly non-geometric, non-metallic and aceramic, and based on a flake element unlike that of northern India where the artifacts are made almost exclusively on blades or micro-blades.

REFERENCES

Aiyappan, A. 1945. Mesolithic artifacts from Sawyerpuram in Tinnevelli district, South India. Spolia Zeylanica. 24(2):145-54.

Foote, R.B. 1914. The Foote Collection of Indian prehistoric antiquities. Madras.

Guzder, S.J. 1980. Quaternary environment and Stone Age cultures of Konkan, coastal Maharashtra, India. Deccan College, Poona.

Joshi, R.V., S.N. Rajaguru, and P. Rajendran. In Press. On the problem of chronology of the Mesolithic industries in Kerala and South Tamil Nadu. Paper presented in a Prehistory Seminar held at Allahabad in 1980.

Krishnaswami, V.D. 1938. Prehistoric man around Madras. Indian Academy of Sciences. 3:32-5.

Rajaguru, S.N. 1973. On the problem of Late Pleistocene climatic changes in western Maharashtra. In Radiocarbon and Indian archaeology (eds D.P. Agrawal and A. Ghosh), pp. 80-7. Bombay.

Rajendran, P. 1979. Environment and Stone Age cultures of North Kerala. Ph.D. Dissertation, Poona University.

------------- 1981. The Palaeolithic industries of north Kerala. Deccan College Bulletin. 40:154-64.

------------- 1982. Silayugasamskaram: Tenmalayile Telivukal. Vijnanakairali. 13(10):637-40.

------------- In Press. The Mesolithic industries of north Kerala. Paper presented at the Xth ICAES Post-plenary symposium on "Recent Advances in Indo-Pacific Prehistory", Pune, 1978.

------------- In Press. The Mesolithic industries of South Kanara. Bulletin of the Deccan College Postgraduate and Research Institute, 1981.

------------- In Press. The coastal Mesolithic industries of South India. Journal of Kerala Studies, 1982.

Zeuner, F.E. and B. Allchin. 1956. Mesolithic sites in Tinnevelli district, Madras State. Ancient India. 12:4-20.

CHEMICAL STUDIES OF ARCHAEOLOGICAL BONES FROM INDIA

R.V. Joshi and Mrs A.A. Kshirsagar
Deccan College, Pune

The application of chemical analysis to material remains found in excavations is a recent development in modern archaeology. Chemical analysis of an archaeological bone can provide information about the fossilization process and the ecological conditions under which it was buried, and it can also give a clue to relative age. The progressive time-dependent chemical alteration of bone, subsequent to burial in sediments, also provides a valuable aid for establishing whether a particular bone is contemporary with other skeletal remains found in the same deposit (Oakley 1969).

However, detailed chemical analysis of fossils has rarely been attempted in India, though many studies have been done on materials from temperate regions. The fluorine content of bone has often been used for relative dating; this technique was first developed in the 19th century and was successfully applied to the Galley Hill skeleton and the Swanscombe skull by Professor Oakley in 1949. The results of fluorine and nitrogen analyses confirmed the antiquity of the Swanscombe skull, but the Galley Hill skeleton was found to be an intrusive burial since it contained low fluorine and high nitrogen.

The initially dense mass of fresh bone becomes, after burial, perforated with millions of extremely fine ramifying open spaces. This is because fats disappear rapidly, while proteins are lost at a slow and declining rate. Nitrogen content is an index of surviving organic matter, and it is often used to give a cross-check for fluorine dating. The changes in the inorganic phosphatic material, hydroxy apatite $Ca_{10} (PO_4)_6 (OH)_2$, are of two kinds:

(a) Addition of new mineral matter involving a change in weight. When bone is desiccated, the inter-crystal spaces vacated by disappearing organic materials may become filled with foreign intrusive mineral precipitates such as calcium carbonate, silica and iron oxide, resulting in dense, heavy and hard fossils.

(b) Alteration of the phosphatic material without a change in weight, through the progressive substitution during burial of fluorine-forming fluorapatite, which is less soluble and more stable than hydroxy apatite. This process is irreversible, and with the passage of time bones in permeable deposits accumulate fluorine progressively.

The chemical changes in a buried bone depend upon the bone texture and chemical composition, and upon the environmental conditions under which it was buried. Other factors such as temperature, water circulation, and the pH and chemical composition of the surrounding groundwater also affect the process. Professor Oakley and other scientists relate the fluorine present not to the weight of total bone but only to the apatite contained in it. Since phosphorus is an integral part of the apatite crystal, the fluorine/phosphorus ratio serves this purpose, and this value is independent of the density of the bone. Cancellous or spongy tissue is liable to contamination by silt or other mineral matter, and in certain instances fossil bone can accumulate these minerals, heavily increasing apparent density and diminishing the observed percentage of fluorine by weight (Cook 1960). Therefore, when a comparison is made between the fluorine/phosphate ratios of different bones this complicating factor is eliminated. The ratio is usually expressed as $100F/P_2O_5$, and the theoretical maximum value of $100F/P_2O_5$ is 8.92.

RESULTS

Table 1 gives some of the results of chemical analyses of bones from Indian archaeological sites of different periods.

Site	Culture/ period	%F	%P	$\frac{100F}{P_2O_5}$	%N	$\%CaCO_3$
Inamgaon (18°35'N 76°35'E)	Chalcolithic	0.037	13.64	0.119	0.056	19.20
Ramapuram (15°05'N 78°05'E)	Chalcolithic	0.053	11.75	0.175	0.051	25.38
Vagad (22°19'N 71°51'E)	Chalcolithic	0.061	10.75	0.248	0.072	39:48
Burzahom (34°10'N 74°53'E)	Neolithic	0.076	9.37	0.471	0.053	14.12
Betamcherla (15°25'N 78°08'E)	E. Holocene	0.954	11.56	3.604	0.026	33.47
Devakachar (23°00'N 79°07'E)	U. Pleistocene	1.259	10.31	5.332	0.024	37.6
Burman Ghat (23°02'N 79°02'E)	U. Pleistocene	2.28	12.19	8.169	0.022	15.84
Pinjor (30°48'N 76°55'E)	Pleistocene	2.47	12.75	8.45	0.022	15.84

Table 1. Chemical analyses - sites of various periods.

It may be observed that fluorine content and the fluorine/phosphorus ratio both increase according to age. Nitrogen disappears as the age of the bone increases, but there is no such trend in the cases of phosphorus and calcium carbonate.

Table 2 gives the mean $100F/P_2O_5$ values of several bones from sites in different geographical regions of India.

Culture/ Period	Jammu & Kashmir	Gujarat	Madhya Pradesh	Mahara-shtra	Andhra Pradesh
Historic	Gufkral 0.158 Semthan 0.120	Tarsang 0.308	-	-	-
Chalcolithic	-	Vagad 0.295 Lothal 0.216 Jekhada 0.505	Eran 0.144 Navdatoli 0.106 Runeja 0.175	Daimabad 0.135 Inamgaon 0.125 -	Ramapuram 0.21 - -
Neolithic	Burzahom 0.206 Gufkral 0.178 Semthan 0.210	-	-	-	Betamcherla 0.34
Mesolithic	-	Tarsang 2.76	-	-	-
Palaeolithic	Sombur 5.076	-	Burmanghat 7.945	Inamgaon 5.40	Betamcherla 3.022

Table 2. Mean $100F/P_2O_5$ values - sites of several periods and regions.

From these two tables it will be clear that there are marked differences in fluorine contents of bones from Chalcolithic/ Neolithic and Palaeolithic sites. $100F/P_2O_5$ values are below 0.5 in bones from Chalcolithic/Neolithic sites in all regions, while they are above 3.0 in the Palaeolithic sites. However, after analysing several bones from Inamgaon (Chalcolithic), it was observed that the method is of limited value for distinguishing

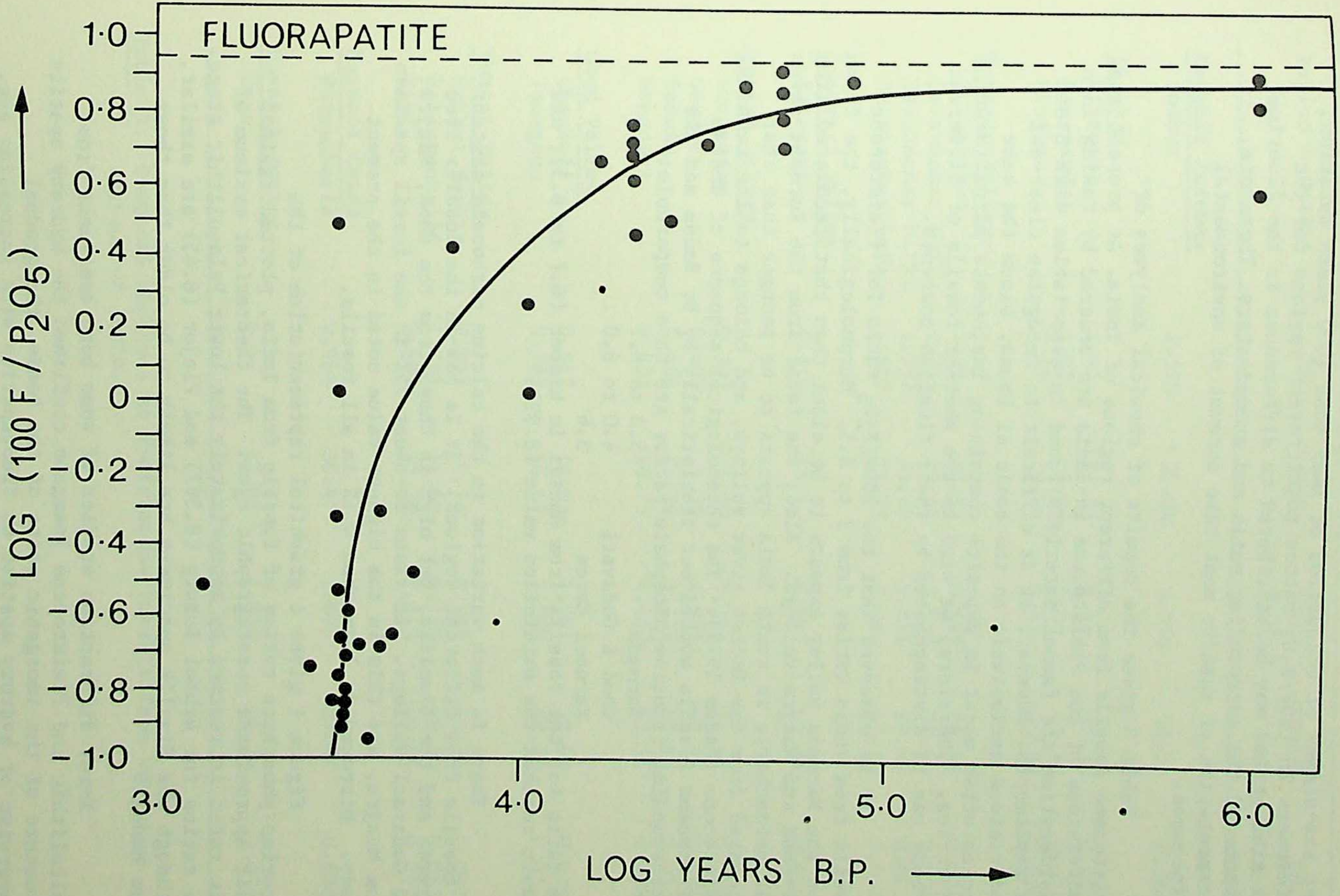

Figure 1. Fluorine/Phosphate Ratios of Fossils from India.

short sub-stages of occupation of less than 1000 years duration. Differences in $100F/P_2O_5$ ratios in different regions for the same time period may be attributed to differences in the fluorine contents of the surrounding soils and groundwaters. Therefore, interpretation of results must take account of environmental differences.

Table 3 gives the results of chemical analyses of Pleistocene fossils from different regions of India. At present the subdivisions of the Pleistocene in India are ordered by taking into consideration the faunal materials found in association with Stone Age implements. However, it is difficult to recognise clear-cut subdivisions exclusively on the basis of fauna, since the same species often occur in deposits containing implements of different industries. Therefore, we wish to see whether fossils of different periods can be distinguished by their fluorine contents.

It is observed that the $100F/P_2O_5$ ratio for Pleistocene fossils from India varies from 3 to 8.5. Morphologically, the fauna from the Narmada valley appears to be older than that recovered from the Ghod and Manjra valleys. Also, the fauna from the Kurnool caves near Betamcherla in south India appears to be younger than that recovered from the Deccan river valleys, and belongs to the terminal Pleistocene (Badam 1979). The chronological sequence of Indian Pleistocene fossils worked out faunistically by Dr Badam and the corresponding fluorine/phosphate ratios are thus comparable:

Narmada	5.3 to 8.1
Ghod & Godavari	4.0 to 6.0
Kurnool Caves	3.6

The ratio for the fossils from Hunsgi is higher (6.7 to 8.3), and almost reaches the saturation value (8.92).

There is much variation in the calcium carbonate content of fossils from different regions. It is low in the fossils from Narmada and the Siwaliks, but high in those from the Ghod, Manjra, and Godavari valleys. It rises to about 75% in one fossil specimen from Manjra, and this is the highest value noted in the present study. Nitrogen is less than 0.1% in all fossils.

Figure 1 gives a graphical representation of the fluorine/phosphate ratios of fossils from India, plotted against their approximate stratigraphic ages. The theoretical maximum of this ratio is reached by approximately the Lower Palaeolithic stage. The ratios for Hebbal Buzurg (8.387) and Pinjor (8.45) are similar, although the Siwalik specimens are likely to be older than those from Hunsgi.

X-ray diffraction studies of some bone specimens from Chalcolithic and Pleistocene Inamgaon confirmed the hydroxy apatite structure of the inorganic parts of the bones, the gradual conversion of hydroxy apatite to fluorapatite with increasing age,

Region & State	%F	P_2O_5	$100F/P_2O_5$	%$CaCo_3$	%N
Kashmir Karewas					
Sombur	1.525	30.04	5.076	14.55	0.068
Siwalik					
Mirzapur	1.45	21.75	6.66	27.73	0.026
Paramandal	1.02	25.46	4.01	11.44	0.017
Pinjor	2.47	29.20	8.45	15.84	0.026
Narmada Valley					
Burmanghat	2.28	28.62	8.169	18.16	0.022
Devakachar U.Pl.	1.259	23.61	5.332	37.60	0.024
Devakachar M.Pl.	1.757	30.04	5.850	20.68	0.022
Devakachar L.Pl.	1.807	22.33	8.08	42.30	0.017
Godavari Valley					
Kalegaon	1.116	18.6	6.00	42.24	0.026
Manjra Valley					
Dhanegaon	0.307	6.00	5.11	74.61	0.022
Ganjur	0.400	8.29	4.825	65.96	0.026
Tadula	0.456	14.59	3.125	43.65	0.051
Wangdari	0.931	20.75	4.487	45.55	0.038
Ghod Valley					
Chandoli	0.642	16.03	4.001	58.08	0.026
Inamgaon	0.983	28.62	5.588	48.70	0.011
Hunsgi Valley					
Hebbal Buzurg	0.902	10.76	8.387	55.29	0.062
Kaldevanhalli	1.116	16.60	6.720	48.50	0.053
Kupi	0.807	10.76	7.513	63.05	0.027
Kurnool Caves					
Betamcherla	0.954	26.47	3.604	33.47	0.038
Coastal region					
Uran	1.14	22.90	4.978	29.10	0.038

Table 3. Chemical analyses of Pleistocene fossils from various regions of India.

and the non-existence of carbonate-apatite in any of the specimens. Therefore, there is no substitution of carbonate for phosphate groups, as was once thought, and hence the fluorine/phosphate ratio holds good for the comparisons.

CONCLUSIONS

The fluorine technique seems to be useful for studying fossilization processes in ancient bones from the Indian environment. To some extent it can also be used for relative dating, but there are limitations. The method gives fairly good results when there are long time differences between samples. It is now necessary to build up complete sequences of results for bones from different periods and from different environments. With this information it should be possible to assign an age to a bone of unknown stratigraphic context when no other means of dating are available.

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REFERENCES

Badam, G.L. 1979. Pleistocene fauna of India. Deccan College, Pune.

Cook, S.F. 1960. Dating prehistoric bone by chemical analysis. Viking Fund Publication in Anthropology No. 28:223-245, New York.

Oakley, K.P. 1969. Analytical methods of dating bones. In Science and Archaeology (eds D. Brothwell and E. Higgs), pp. 35-45. Thames and Hudson, London.

CHEMICAL STUDIES OF OCCUPATION SOILS IN INDIA

Bhaskar C. Deotare
Deccan College, Pune

Chemical analyses of occupation soils are useful aids to studies of abandoned human settlements. Human occupation increases concentrations of elements such as carbon, nitrogen and phosphorus, and this alteration is cumulative and measurable by chemical analysis.

The fertility of an occupation soil is usually higher than that of surrounding soils. In India, habitation mounds are often destroyed by farmers who use the soil to fertilize their fields. They are aware that these deposits are rich in essential plant nutrients which significantly increase crop production. This high fertility of occupational debris is due to the residue of chemical elements contained in plant food materials, human and animal excreta, urine, human burials, and food bones.

The chemical elements which are of greatest importance from an archaeological point of view are carbon, nitrogen and phosphorus. Average concentrations of these elements in various natural soils (agricultural and non-agricultural) are given in Table 1.

	pH	Organic Carbon %	Nitrogen %	Phosphorus %
Black soil	8.2	0.5	0.03	0.06
Alluvial soil	6.3	0.4	0.04	0.04
Red soil	5.4	0.2	0.002	0.006
Forest soil	6.6	1.5	0.25	0.09
Desert soil	8.8	0.2	0.02	0.009

Table 1: Average nutrient concentrations in some Indian soils (from Govinda Rajan and Gopala Rao 1978)

Carbon and nitrogen are added to inhabited areas in relatively large quantities as a result of human activity, but they are easily lost through leaching, oxidation and reduction. However, although the total quantity of phosphorus in any soil is small due to its low solubility and restricted movement, the possible loss by leaching is almost nil, except through erosion (Duma 1972; Eidt 1977).

Phosphorus fixation in soils occurs mainly through reaction with hydrolysed iron and aluminium oxides, and with calcium and magnesium compounds. It may also become adsorbed on the surface of clay particles or form complexes with clay minerals (Mizota 1977). Thus, of all the chemical elements introduced into soil through human activity, phosphorus is the most accurate index of the extent, intensity, duration and nature of human settlement.

With a view to testing the applicability of chemical analysis to the study of anthrosols in India, experiments were carried out at several sites, ranging in date from Stone Age to Early Historic. Nearly 500 soil samples were collected from archaeological sites situated in various parts of the country; 400 samples were from actual habitational areas, and about 100 were from non-habitational areas including adjacent fields as well as virgin soils underlying the archaeological deposits. All these samples were analysed for organic carbon, nitrogen and phosphorus by standard methods. Electrical conductivity and pH values were also determined to understand the nature of the salts present in the deposits.

Data on all the samples collected from vertical sections were computerized in order to investigate the behaviour of carbon, nitrogen and phosphorus. From the computer analysis it appears that the values of these elements vary from site to site, and even within layers of the same site (Deotare and Joshi 1981). Since carbon and nitrogen are relatively unstable, and subject to microbial activity and oxidation in arid and semi-arid conditions, no significant variations between habitation and non-habitation areas were observed (Table 2). However, phosphorus concentrations in habitation deposits range between 4 and 10 times more than those in adjacent non-habitation deposits.

From Table 2, the following observations can be made:

1. Almost all samples are alkaline with a pH above 7.0, except at Bhimbetka and Thebronggiri where the deposits are acid with a low electrical conductivity, owing to heavy rainfall.
2. For organic carbon and nitrogen no definite trends can be observed, and these two elements cannot be considered indicative of the character of a settlement.
3. Concerning phosphorus, all deposits from habitational areas contain more than 0.10%, while in non-habitational deposits it ranges from 0.02 to 0.10%. Thus, if a phosphorus content is more than 0.1% it is an indication of human habitation, and more positively so if the value is more than 0.2%.
4. At the protected Palaeolithic cave site of Betamcherla a phosphorus value of 0.35% was obtained, but the open-air

Cultural period	Site	Number of samples	pH	E.C.	O.C.%	N %	P %
Early Historic	Dangwada	8	8.9 (8.3)	0.50 (0.20)	0.31 (0.44)	0.06 (0.07)	0.28 (0.03)
	Nagdandi	2	7.6 (7.2)	0.16 (0.05)	1.18 (0.33)	0.15 (0.06)	0.31 (0.08)
	Semthan	4	8.3 (8.5)	6.1 (0.22)	0.56 (0.23)	0.09 (0.05)	0.32 (0.07)
	Satanikota	2	9.0 (7.6)	0.47 (0.23)	0.45 (0.44)	0.05 (0.06)	0.40 (0.04)
	Somnath	4	8.1 (8.8)	1.47 (0.50)	0.72 (0.46)	0.11 (0.01)	0.47 (0.06)
Megalithic	Mahurzari (Stone-circle)	8	(7.6)	(0.14)	(0.58)	(0.04)	(0.05)
	Satanikota (-do-)	9	(8.3)	(0.22)	(0.19)	(0.02)	(0.06)
	Naikund (-do-)	7	(7.7)	(0.23)	(0.35)	(0.02)	(0.05)
	Naikund	32	8.0 (8.2)	0.25 (0.21)	0.56 (0.26)	0.06 (0.03)	0.34 (0.06)
	Virapuram	2	9.3 (9.0)	1.1 (0.72)	0.21 (0.18)	0.02 (0.01)	0.51 (0.07)

Table 2. Mean percentages of carbon, nitrogen and phosphorus in deposits from Indian archaeological sites.

Cultural period	Site	Number of samples	pH	E.C.	O.C.%	N %	P %
Chalcolithic	Mandsaur	7	9.4	0.5	0.31	0.06	0.21
	Rupar	3	8.2 (8.8)	6.3 (1.8)	0.45 (0.21)	0.11 (0.06)	0.26 (0.03)
	Inamgaon	68	8.3 (8.8)	4.2 (0.3)	0.78 (0.35)	0.08 (0.02)	0.30 (0.06)
	Dangwada	6	8.6 (8.3)	1.6 (0.20)	0.34 (0.44)	0.06 (0.07)	0.31 (0.03)
	Apegaon	18	8.1 (8.0)	1.3 (0.8)	0.84 (0.58)	0.05 (0.03)	0.33 (0.10)
	Daimabad	85	8.5 (8.2)	2.6 (0.7)	0.68 (0.68)	0.06 (0.03)	0.35 (0.06)
	Ahar	11	9.4 (8.1)	24.2 (20.0)	0.34 (0.34)	0.03 (0.02)	0.37 (0.08)
	Somnath	2	8.8 (8.8)	0.9 (0.5)	0.53 (0.46)	0.29 (0.01)	0.57 (0.06)
	Jodhapura	8	8.1 (8.4)	15.0 (11.5)	0.41 (0.16)	0.17 (0.07)	0.65 (0.04)
Neolithic	Thebronggiri	1	4.2 (3.9)	0.05 (0.02)	0.94 (0.64)	0.05 (0.02)	0.19 (0.06)

Table 2 continued

Cultural period	Site	Number of samples	pH	E.C.	O.C.%	N %	P %
	Virapuram	3	8.6 (9.0)	1.68 (0.72)	0.19 (0.18)	0.03 (0.01)	0.20 (0.07)
	Burzahom	16	8.5 (8.1)	0.8 (0.4)	1.01 (0.44)	0.10 (0.07)	0.45 (0.07)
	Kudutini	3	8.8	0.5	0.47	0.07	0.55
	Kupgal	4	8.6	3.8	0.36	0.04	0.70
	Sangankallu	4	9.1	7.5	0.67	0.12	0.68
Harappan	Kalibangan						
	- Residential area	5	8.4	13.5	0.24	0.11	0.29
	- Citadel	8					0.14
			(8.0)	(1.5)	(0.29)	(0.07)	(0.07)
	Rupar	4	8.0 (8.8)	10.0 (1.8)	0.32 (0.21)	0.14 (0.06)	0.28 (0.03)
	Lothal	9	8.2 (8.4)	17.0 (0.2)	0.13 (0.32)	0.03 (0.03)	0.31 (0.06)
Mesolithic	Iddinda karai	2	7.7 (8.3)	0.7 (0.8)	0.32 (0.12)	0.06 (0.009)	0.14 (0.04)
Palaeolithic	Khandera	19	6.7	0.11	0.79	0.06	0.05
	Bhimbetaka	12	4.2	0.08	0.30	0.03	0.14

Table 2 continued

Cultural period	Site	Number of samples	pH	E.C.	O.C.%	N %	P %
	Hunsgi	2	8.5	0.6	0.28	0.04	0.14
	Betamcherla	11	7.7	0.8	0.62	0.09	0.35

E.C. = Electrical conductivity in millimhos/cm.

O.C. = Organic Carbon

Figures in brackets are for sterile or non-habitation deposits.

Table 2 continued

Acheulian site of Khandera gave a very low (0.05%) phosphorus reading, mostly due to loss through run-off and erosion.

5. The Harappan sites of Lothal, Kalibangan and Rupar respectively gave 0.31, 0.29 and 0.28% P. These values are almost identical and show a high intensity of cultural activity.

6. The Neolithic sites of Sangankallu, Burzahom, Virapuram and Thebronggiri gave readings of 0.68, 0.45, 0.20 and 0.19% P respectively. The high values at Sangankallu (and also Kupgal and Kudutini) result from ash mound formation.

7. The maximum numbers of samples from specific sites so far studied are from the Chalcolithic sites of Inamgaon and Daimabad, both with identical environmental conditions, where the average phosphorus contents are 0.30 and 0.35% respectively. At Inamgaon, the phosphorus content is relatively low (average of 0.26%) in the Malwa levels, but it is higher (0.34%) in the Early Jorwe levels (Table 3).

8. In Chalcolithic sites other than Inamgaon and Daimabad the percentage of P is much the same, as at Ahar, Apegaon, Dangwada and Rupar. It is high at Jodhapura and Somnath as a result of the higher intensity of occupation. By and large the values of P for all the Chalcolithic sites are similar and it may be assumed that settlement sizes differed little.

9. The Megalithic sites of Naikund and Virapuram gave 0.34 and 0.51% P. The Virapuram site is well preserved, and judging from the thickness of the deposit the occupation may have been more intensive than at Naikund.

10. The Early Historic sites of Semthan, Nagdandi and Dangwada gave 0.32, 0.31 and 0.28% P respectively, without much variation. The high P values for Satanikota and Somnath show a higher intensity and duration of habitation.

11. The samples of occupation soils from all sites averaged 0.33% P, while all the non-occupation soils averaged 0.06% P. This significant difference demonstrates the usefulness of phosphate analysis in archaeological investigations.

The method can also be applied to confirm a break in a habitation sequence. In this regard the results from Rupar, Virapuram and Dangwada are very interesting (Table 4). At Rupar, samples from the sterile layer between the Harappan and Painted Grey Ware periods contain only 0.06% P, which indicates abandonment of the site at this time. Similarly, in the profile of Virapuram a sterile layer between the Neolithic and Megalithic occupations gave readings of 0.07 and 0.08% P. These values are very close to those

Culture	Description	Layer	pH	Phosphorus %
Late Jorwe	House No. 63	8	7.6	0.32
	House No. 63	8	7.7	0.29
	Inside house No. 65	8	7.6	0.33
	Outside house No. 65	8	8.2	0.40
	House No. 67	8	8.0	0.38
	House No. 68	8	8.1	0.27
	House No. 69	8	8.3	0.49
	House No. 71	8	7.6	0.46
Early Jorwe	House No. 75	12	7.9	0.25
	Inside house No. 78	12	8.8	0.29
	Outside house No. 78	12	9.2	0.13
	House No. 79	12	9.4	0.29
	House No. 80	12	8.0	0.29
	House No. 85	12	8.5	0.43
	House No. 85	12	9.4	0.42
Malwa	House No. 91	14	8.1	0.41
	Sealing soil of house No. 91	14	7.6	0.17
	Sample of decomposed grass in house No. 75		8.4	0.16
	Sample of decomposed grass of roof or side wall		9.0	0.18

Table 3. Results of analyses of house deposits at Inamgaon.

Culture/Period	pH	Phosphorus %
Rupar		
Painted Grey Ware	8.6	0.30
Sterile layer	8.5	0.06
Sterile layer	8.1	0.06
Harappan	8.0	0.29
Virapuram		
Megalithic	9.1	0.62
Sterile layer	9.0	0.08
Sterile layer	9.1	0.07
Neolithic	8.4	0.23
Dangwada		
Shaka	9.0	0.23
Sterile layer	9.3	0.07
Shunga	9.5	0.17

Table 4. Results of chemical analysis of deposits from Rupar, Virapuram and Dangwada.

for the virgin and modern soils. A layer between the Shaka and Shunga occupations at Dangwada also has a very low (0.07%) phosphorus content.

In order to delimit the extent of habitation, a rapid phosphate field spot-test was applied at the Chalcolithic site of Inamgaon. By testing several samples on the site, significant values could be plotted until non-significant values were obtained. The extensive horizontal excavations at Inamgaon and Daimabad also gave opportunities to test samples collected from the different activity areas exposed. In Inamgaon, the horizontal distribution of phosphorus in the bottom layer of period III (Late Jorwe) gives some idea about the house-wise activities of the people. Phosphorus contents are 0.49 and 0.46% in houses 69 and 71 respectively, thus incidating high concentrations of occupation here (Table 4). In the Malwa levels, samples of decomposed grass from roofs or walls contain 0.16 and 0.18% P. However, a sample from house No. 91 contained 0.41% P, whereas the soil which overlay the same house gave only 0.17% P. This low phosphorus content in the overlying soil suggests that the sample might have come from a collapsed roof layer.

In layer 5 of the Malwa period at Daimabad the phosphorus content is higher than in the Jorwe layers, and ranges from 0.23 to 0.50%. These high phosphate contents are suggestive of a high density of population during the Malwa period. In layer 9 of the late Harappan period only slight variations in phosphorus content were observed, with one or two exceptions. Most samples are between 0.23 and 0.33% thus indicating a lesser intensity of occupation than in the Malwa period (Table 5). However, it should be stated that it is not possible to quantify actual population densities without comparisons with modern settlements with known values for human as well as animal populations.

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REFERENCES

Deotare, B.C. and R.V. Joshi. 1981. Behaviour of carbon, nitrogen and phosphorus in archaeological deposits from India. Bulletin of Deccan College Research Institute. 40:95-112.

Duma, A. 1972. Phosphate content of ancient pot an indicator of use. Current Anthropology. 13:127-130.

Eidt, R.C. 1977. Detection and examination of anthrosols by phosphate analysis. Science. 197:1327-1333.

Govinda Rajan, S.V. and H.G. Gopala Rao. 1978. Studies on soils of India. Vikas Publishing House, New Delhi.

Mizota, C. 1977. Phosphate fixation by Ando soils; difference in their clay mineral composition. Soil Science and Plant Nutrients. 23(3):311-318.

Culture	Layer	Depth in cm.	pH	Phosphorus %
Jorwe (Sector II)	top 2	20	8.1	0.28
" "	"	"	8.9	0.25
" "	"	"	8.3	0.31
" "	"	"	8.6	0.36
" "	"	"	8.8	0.25
" "	"	"	8.3	0.25
" "	"	"	8.3	0.33
" "	"	"	8.4	0.22
" "	"	"	8.6	0.14
" "	"	"	8.2	0.25
" "	"	28	8.5	0.34
" "	"	"	8.7	0.38
" "	"	"	8.4	0.39
" "	"	"	8.5	0.28
" "	"	"	9.1	0.31
Malwa (Sector II)	top 5	123	8.1	0.32
" "	"	"	8.0	0.39
" "	"	"	9.0	0.27
" "	"	"	8.1	0.23
" (Sector IV)	"	125	9.2	0.41
" "	"	"	8.6	0.36
" "	"	"	8.5	0.50
" "	"	"	8.8	0.41
" "	"	"	8.8	0.44
" "	"	130	8.8	0.46
" "	"	"	9.2	0.36
" "	"	"	8.4	0.41
" "	"	"	8.4	0.44
Late Harappan	top 9	205	8.5	0.29
" "	"	"	8.6	0.23
" "	"	"	8.9	0.26
" "	"	"	8.7	0.14
" "	"	"	8.7	0.32
" "	"	"	9.2	0.33
" "	"	"	8.9	0.22
" "	"	"	8.9	0.31
" "	"	"	9.2	0.58
" "	"	"	8.8	0.32

Table 5. Results of analysis of deposits from Daimabad.

SOCIETY AGAINST THE STATE: PERSPECTIVES ON THE HISTORY OF EARLY ANDHRA PRADESH

Amareswar Galla
Australian National University

In most historical literature the concept of the 'State' and its organization has become a yardstick for measuring the degree of civilization achieved by any society. Such a Eurocentric notion has often precluded the understanding of local processes of power. This paper is a summary of a monograph in preparation which attempts to study such processes in early Andhra Pradesh in tropical South India (Fig. 1), between the third century B.C. and the mid-fourth century A.D.[1] The research has shown that one of the most advanced cultures of early India in fact resisted, or did not exhibit, many of the conditions that are normally used to define a state apparatus.

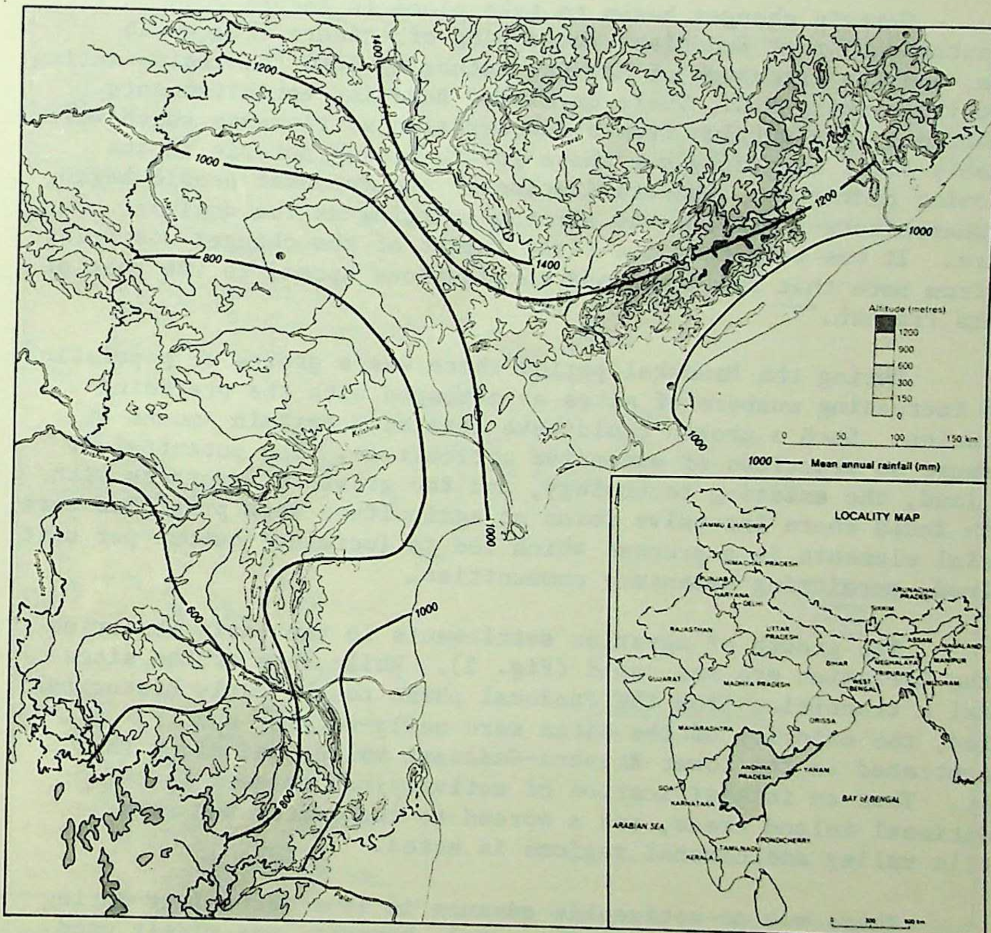

Figure 1. Relief and Mean Annual Rainfall, Andhra Pradesh.

For convenience, the period under study has been divided into two phases based on the dominant cultural remains. The first, dealing with the three centuries prior to the Christian era, is marked by the burials of the Pandukal (Megalithic) complex of the early Iron Age of South India. The second phase, comprising the following four centuries, is dominated by early historical settlements and monuments and a large corpus of inscriptions which mainly concern donations made to Buddhist establishments.

The Pandukal people operated mainly in the drier inland districts, practising both pastoralism and a semi-sedentary form of agriculture, and cultivating food grains that were more suitable for dryland farming. Cultivation was mainly done with hoes rather than ploughs, and some rudimentary irrigation was practised. Although Pandukal people were better equipped than their Neolithic predecessors through their acquisition of iron technology, their use of this metal was restricted to weapons. Its importance to agriculture was only realized in subsequent centuries.

Certain changes began to take place in Andhra Pradesh with the introduction of Buddhism, the coming of traders from North India, and the extension of Mauryan authority into the region during the third century B.C. There developed Buddhist establishments supported by the surplus from a few agrarian settlements which were probably small initially but whose growth became notable in the following centuries. Sedentarization of the Pandukal people began, and Dharanikota-Amaravati was already emerging as the dominant centre. It was here that the first impact of the changes was felt, and from here that new ideas and institutions spread to the rest of Andhra Pradesh.

During the Pandukal period there was a growth of population with increasing numbers of sites as compared with the preceding centuries. Such a growth could have created a certain amount of pressure on practices of extensive agriculture. The potential of the land, the existing technology, and the growth of contacts with North India where intensive forms of agriculture were practised were crucial elements in a process which led to increased output per unit of land, permitting sedentary communities.

The growth of agrarian settlements in the early centuries of the Christian era was rapid (Fig. 2). While some of the sites reveal a transition from the Pandukal phase to the early historical period, the majority of the sites were newly-settled and concentrated in the lower Krishna-Godavari valley and along the coast. Thus an intensification of activity can be seen in the traditional inland areas, and a spread to the wetter but more fertile valley and coastal regions is noted.

There was no noticeable advance in iron technology during the early historical period. The metal, however, was widely used.

Ploughs and wet rice cultivation came into vogue, and there was a definite advance in irrigation skills. Apart from food crops, including the different strains of rice, cash crops such as cotton were also grown - apparently on a significant scale.

The process of change was one in which a large amount of labour input was an important factor in increasing agrarian production, and the transition from extensive to intensive agriculture was accompanied by increasing social stratification. The earlier clans of the Pandukal people had undergone changes, and the grhapati emerged as a social category. Grhapatis were heads of large patrilineal households, and the labour required for intensive agriculture was organized around these households where the land controlled by them was cultivated by members of the family; labourers probably were hired.

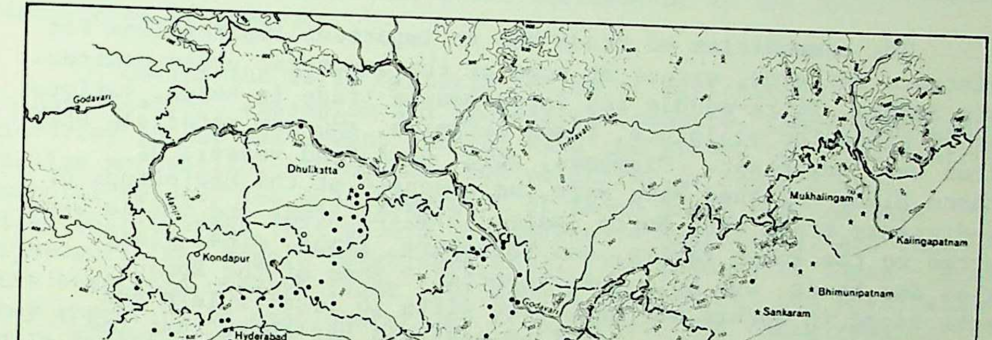

Figure 2. Archaeological Sites in Andhra Pradesh, 300 B.C.-A.D. 300.

With the intensification of agriculture and correlated changes there was a development of nuclear modules or small territorial units. These are ecologically and historically defined, and have a central place or dominant centre around which the subordinate territory becomes a supporting hinterland. Such centres within urbanising communities became the foci of economic activity, social interaction and the evolution of local power structures. The grhapatis emerged as the powerful elites in these modules, controlling not only land but also exchange networks, and became the substructures of the urbanising communities.

It is beyond question that there were trading networks during Pandukal times, and that these increased rapidly during the early historical period. The development of long distance trade with regions outside was important in the introduction of new ideas, and had a crucial bearing on the local processes of development of hierarchies of power. In certain respects, traders accompanied by Buddhist monks opened up Andhra Pradesh to the rest of the subcontinent.

The commodities of trade had no important implications for subsistence patterns, except at some of the important urban centres. Within Andhra, intra-module and inter-module trade in beads, various types of stone for sculpture, trade ceramics, and raw materials such as iron were important. Diamonds, gold, gems, and vessels of Northern Black Polished Ware were the essences of the beginnings of long-distance trade with North India. Similar items and muslin were exported to the Roman Empire, and tableware, lamps, wine, glass bangles and beads, and gold were imported. Some of the Roman objects found in Andhra may have been gifts to local rulers and powerful, wealthy traders. Detailed analysis has shown that the Roman Empire, however, does not appear to have suffered an adverse balance of trade - contrary to an earlier, very widespread view.

While the advent of coinage in the region was associated with the beginnings of long-distance trade with North India during Pandukal times, it was only during the first century A.D. that local coinage came into vogue. Coins of precious metals, both Roman and Indian, had a limited use and were hoarded or converted into prestige goods. Coins of base metals, on the other hand, facilitated local transactions within the context of long-distance trade.

The extension of Sātavāhana authority and coinage into the coastal districts was simultaneous with the growth of maritime trade in the region, and the very distribution of coins along the principal trade routes points to a monetary economy facilitating essentially long-distance rather than local trade. The association of coinage with long-distance trade is further testified to by certain issues of Sātavāhana coins which were minted in order to further trade with the Roman Empire and with Southeast Asia.

Although evidence for the use of coin money is available, barter as a form of exchange must have continued to play an important role in everyday life. Metal coinage never penetrated the agrarian sector nor created an economic infrastructure to sustain its usage. It is not then surprising that it gradually disappeared in subsequent centuries with the diminishing importance of the region in the long-distance trade of the sub-continent.

The grhapatis invested agricultural surplus in trade, and early craft production probably was centred around the patrilineal household. In the early centuries A.D., some craftsmen became full-time specialists. The artisans and merchants formed guilds, which were important not only in the organization of craft production but also in their roles as banks financing industry. These guilds became essential features of the urban centres, and the heads of these corporate bodies became quite influential in the local hierarchies of power.

During the early historic period of agricultural intensification, expansion and increasing commerce, there appeared a hierarchy in the settlement pattern with the growth of urban centres filling mercantile, ceremonial, and political or regal-ritual cultural roles. The most important of these urban centres were first Dhānyakaṭaka (the modern Dharanikota - Amaravati), and then Vijayapurī (the modern Nagarjunakonda). The remains at these places were scattered over at least four square kilometres, and physically they appear to be conglomerations of hamlets. But these remains, while functionally diverse, are definitely complementary and interdependent.

If the Mauryan Empire (ca. 313-200 B.C.) was a rare period in the sub-continent, with a single politically united state, this certainly was not a centralizing state. The flexible Mauryan administration adapted to regional or local conditions outside the heart of the empire. The extension of Mauryan authority into Andhra Pradesh led to the stationing of North Indian officials or administrators at crucial trade points. These persons do not appear to have organized politics at the local level, and their roles may have been to keep up the flow of tribute from the local chieftains and kings, to facilitate long-distance trade, and to help the diffusion of Buddhism. The local Pandukal people, by controlling the trade, especially in prestige goods such as gold, diamonds and precious stones, may have acquired substantial power.

The martial nature of the grave goods from the hundreds of Pandukal burials suggests not only a violent but also an expanding tribal system. In such a context of endemic danger, it was only natural that Pandukal chieftains should acquire power, and they already controlled the local exchange networks. These emergent paramount chiefs acquired even greater power through their associations with the Mauryan traders and officials. The local chieftains probably had accepted allegiance to the Mauryan authority, and it is not surprising then that some of them established themselves as kings, emulating their predecessors in subsequent centuries.

These rulers operated from citadels in the various urban centres, and controlled not only the respective nuclear modules, but also the principal trade routes that ran through them. The control of prestige goods which characterised the contemporary long-distance trade would undoubtedly have been quite crucial. Is it then surprising that the Sātavāhanas should have extended their authority into Andhra Pradesh from the adjacent region of Maharashtra to benefit from the increasing maritime commerce, and that they should have issued coinage of considerable variety to facilitate transactions? With the proliferation of agrarian settlements in the early historical period the number of nuclear modules increased. These formed the different building blocks which the Sātavāhanas and Ikṣvākus brought together into a pyramidical structure, where tribute and not taxes was crucial. This pyramidical structure was articulated through marriage alliances and the circulation of prestige goods.

The alliances were characterised by a complicated strategy of marriage-forging. This was achieved not only through the daughters and through the many queens, but also through cross-cousin marriages crucial in the consolidation of the ruling élite. Women were not only given to the lower-ranking aristocracy, but they were also taken from them. The rather conspicuous number of donations made by women at Nagarjunakonda, the capital of the Ikṣvākus, becomes very important in this context. A number of these represented aristocratic families which were scattered all over Andhra in the various nuclear modules. The women who married into the royal family, or the princesses from the latter who were given in marriage, must have been important political representatives, at least in a symbolic way. It is not then surprising that these women should have exhibited such wealth in their donations. Some of the lay women who made donations must also have come from very influential families of householders and traders.

Buddhism provided a significant religious impulse to the evolution of early Andhra culture. The various architectural forms of places of worship, with stone forming an important material, suited the local Pandukal people whose beliefs centred around the dead and around stone. Vedic ritualism and devotional cults also made their impact by the beginning of the present era. They were patronized mainly by the kings of the region, who probably sought to legitimize their authority with the help of the Brahmins. With the women of the royal family mainly patronizing Buddhism, the ruling groups of Andhra Pradesh seem to have catered well for the ideological support of their own authority.

In fact, the developments towards Mahāyāna Buddhism and the growth of Purānic religions or devotional faiths provided the ideological dimensions for the symbolic and ritual integration of the different nuclear modules into a pyramidical structure, first under the Sātavāhanas and then under the Iksvākus. Although with the extension of Mauryan authority into Andhra Pradesh there appeared a possibility for the development of a unified state apparatus, with the regional processes of power the necessity for such a unified state did not exist. Was it a case of the society at large resisting the imposition of a superstructural state?

FOOTNOTE

[1] I would like to acknowledge Professor A.L. Basham, Mr K. Cowan, Ms M. Burns and my teachers at Jawaharlal Nehru University, New Delhi.

PRELIMINARY REPORT ON ARCHAEOLOGICAL SURVEY AND EXCAVATIONS IN THE PHIMAI REGION, NORTHEAST THAILAND

David J. Welch
University of Hawaii

PROJECT BACKGROUND

Based on the examination of aerial photographs, Williams-Hunt (1950) first noted the presence of over 200 archaeological sites apparently fortified by earth walls and moats along the Mun and Chi Rivers in the Khorat Basin of northeast Thailand. Since that time archaeological fieldwork has been conducted at only a few of these sites, namely Muang Sema and Muang Fa Daed by the Fine Arts Department of Thailand (Wales 1969, Subhadradis 1956), Ban Thamen Chai and Muang Phet by Wales (1957), and Non Dua by Higham and Parker (1970, Higham 1977). After mapping the location of over 400 fortified sites from aerial photographs, Thiva and Srisakra (1972) warned that many of them were in danger of destruction prior to archaeological field investigations. Therefore, the Khorat Basin Archaeological Project was organized to carry out archaeological survey and test excavation of fortified sites in the upper Mun River valley. The National Science Foundation provided funding through a dissertation research grant to the author, and the Fine Arts Department (FAD) of Thailand sponsored the research. Praphid Phongsmas, a FAD official, participated as co-researcher and a field supervisor, Professor Promsak Jermsawatdi supervised the work of three students from Chulalongkorn University during the Ban Tamyae excavations, and Judith McNeill acted as assistant project director.

The basic objectives of the project are to:

1. Determine the location of the fortified sites in the survey area, their size, present condition of the earthworks, and the type of archaeological remains associated with each site, and to prepare a map of each site.

2. Establish a local ceramic sequence for relative dating of the sites, and, if possible, to obtain radiocarbon dates from stratified deposits to provide calendrical dates for the sequence.

3. Ascertain the probable function of the earthworks and moats and the time at which they were constructed.

4. Test the hypothesis that an intensive agricultural system involving use of the plow and water control was used by the inhabitants of the fortified sites.

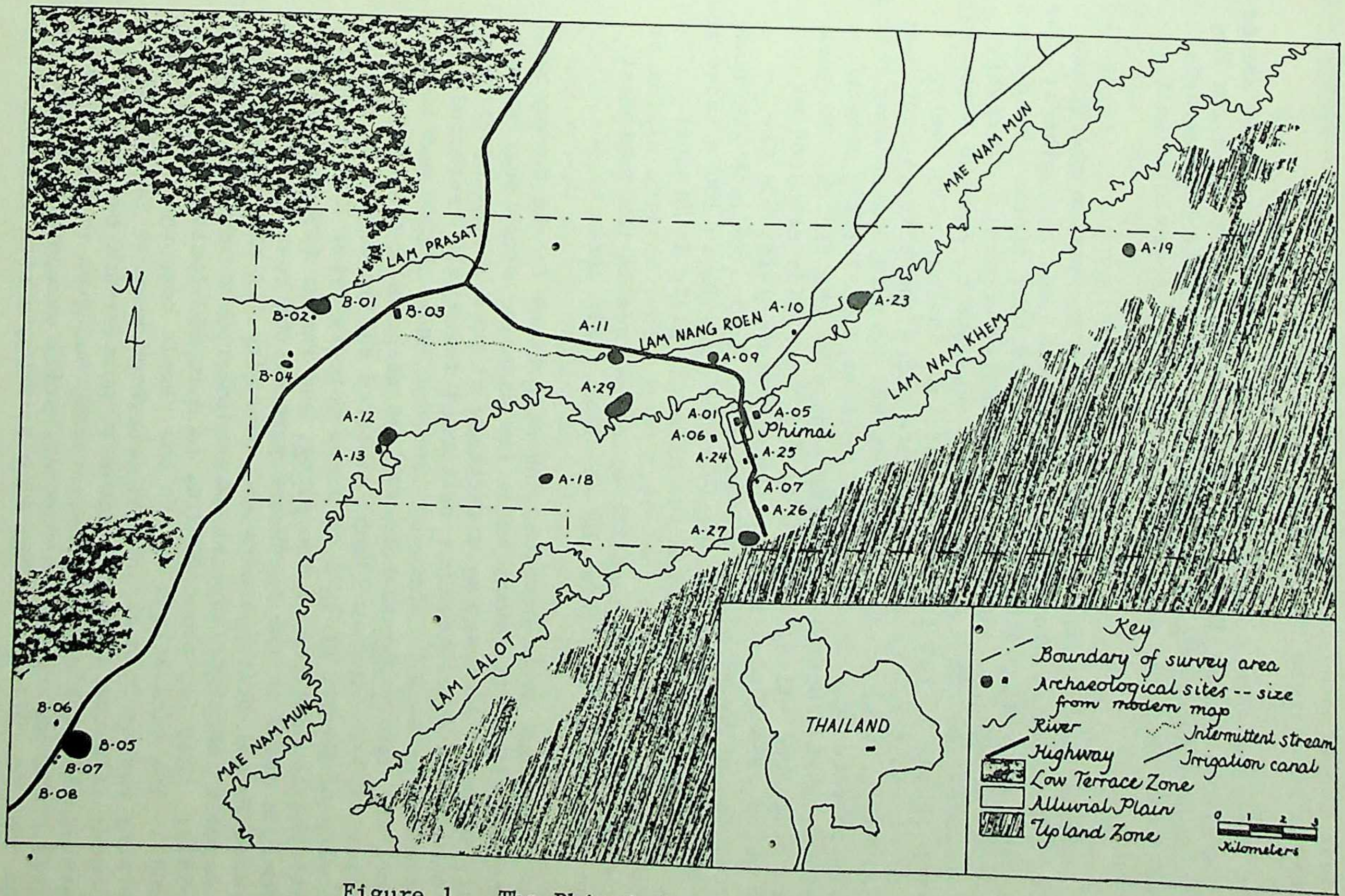

Figure 1. The Phimai Survey Area.

5. Test the hypothesis that the fortified towns were regional exchange centers for long distance trade.

The area selected for initial investigation centered around Phimai, a district administrative center and market town on the Mun river in Nakhon Ratchasima province. The rectangular survey area extended 15 km east and west and 5 km north and south of Phimai (Figure 1).

Three major environmental zones are present in the Phimai region: the alluvial plain, the low terraces, and the uplands. The broad, flat alluvial plain, covered by diked rice fields, is drained by numerous meandering seasonal and perennial streams. Rainfall, which averages 1200 mm a year, is just adequate to produce a single rice crop annually, but the Phimai and Kula Ronghai clay soils, which cover about 75% of the plain, are among the best in northeast Thailand for growing rice. West of Phimai farmers depend upon rainfall to water the fields, while northeast of Phimai, modern irrigation canals control the water supply to the fields. Farmers live in clustered villages of 70 to 300 households situated on mounds which rise 1 to 5 m above the alluvial plain. To the southeast the alluvial plain ends abruptly 3 to 5 km from the river where forested hills rise gradually to heights 70 to 100 m above the plain. Northwest of the river the alluvial plain is broader, extending 10 to 15 km from the river to the low, rolling plains of the low terrace zone. Except for hilly uplands in the southeast, the survey area falls within the alluvial plain zone.

Previous archaeological investigations in the survey area have been confined to Phimai and a few historic sites near Phimai. Phimai, formerly enclosed by a rectangular wall and moat, is the site of a large Khmer temple constructed during the tenth and eleventh centuries A.D. Between 1963 and 1968, UNESCO and FAD restored the main prang (sanctuary) and prepared a town map (Groslier 1963). Solheim (1965) reported the discovery by the FAD-University of Hawaii project of a new pottery type, Phimai black, beneath the foundations of the prang, and Parker (1966) excavated Ban Suai, a mound in the southeast part of the town, where he recovered Phimai black pottery and iron slag. A charcoal sample from Layer 6 (of eight layers) was radiocarbon dated 1930 ± 100 B.P. (Gak-991); that is, about 20 B.C. to A.D. 160 (Solheim and Ayres 1979:68). Two excavations within the temple compound by Silpakorn University and by Peacock in 1969 uncovered several layers of structural fill containing "Dvaravati" pottery and burials containing Phimai black pottery, bronze, and iron (Bronson 1976:671, 709-712). FAD has conducted further, still unreported, excavations at Ban Suai in 1977 and at Tha Nang Sa Phom, a site previously surveyed by FAD (1959).

SITE SURVEY

Between December 6, 1979 and January 25, 1980 a four member team surveyed sites within the survey area and a few additional sites. A map by Thiva and Srisakra, identifying thirteen fortified sites in the Phimai area from aerial photographs, was generously provided by Srisakra and served as the original guide to site locations. The survey team surveyed these sites, all mounds, and other mounds within the survey area. While a few small mounds may have escaped attention, I feel that the survey has located the great majority of sites of this type within the project area. Intensive, reconnaissance surveys of a few non-mound areas found only concentrations of modern sherds, probably marking the site of recent field huts, and a few reservoir basins and embankments.

Villages are located on most of the mounds. At each inhabited site, the survey team interviewed the headman or his assistant and drew and photographed artifacts in local collections. Each site was mapped with tape and compass, and the elevation of the mound along two axes measured at 10 m intervals. At two sites, Ban Samrit and Ban Prasat, roads had been cut through the mound, making it possible to collect a stratified sample of artifacts from the exposed faces. At these sites and at Non Ban Kham and mound NR-A-08 subsurface samples were collected by coring with a soil auger.

Twenty-four sites, including a walled town, fifteen habitation mounds, and five religious shrines, were identified within the survey area. Three reservoirs near Phimai were assigned separate site numbers, but nine additional reservoirs are associated with various habitation mounds. Of the thirteen potential fortified mounds, twelve contain evidence of former human occupation and eight possess features that may be remnants of former earth embankments and moats. Most of the mounds, which are fairly clearly habitation sites, are located on the banks of the Mun river or other watercourses. Mounds may be circular, oval, rectangular, or square, and vary from 1 to 22 hectares in area. Within this range, sites appear to cluster into three size categories. Six sites are less than 5 hectares, five sites are between 13 and 17 hectares, and two sites are approximately 22 hectares. We were unable to measure the spatial extent of two sites. Two small sites may be the result of population expansion from nearby large sites.

Table 1 lists the sites identified during the survey, including sites outside the survey area; Ban Bing, a mound 22 km southwest from Phimai, small mounds near Ban Bing, and Ban Krabuang, a mound in the low terrace zone 32 km northeast of Phimai. Figure 1 shows the location of sites in the survey area.

Site No.	Name	Approx. Size (Hectares)	Ceramic Tradition T	P	EH	LH	Earthwork Remnant Wall	Moat
	Habitation Mounds							
NR-A-04	Ban Suai	15	–	X	X	X	–	–
NR-A-09	Ban Nang Roen	1.8	–	?	X	X	–	–
NR-A-10	Non Ban Kham	2.3	X	X	X	X	X	?
NR-A-11	Ban Tamyae	17	X	X	X	X	X	X
NR-A-12	Ban Samrit	22	–	X	X	X	X	X
NR-A-13	Ban Samrit Mai	4.5	–	X	X	X	–	–
NR-A-18	Ban Khla	1.5	–	?	X	X	–	–
NR-A-19	Noen Phaeng Phuai	16	–	?	X	X	X	X
NR-A-23	Ban Tha Luang	16	–	X	X	X	X	?
NR-A-27	Ban Wang Hin *	–						
NR-A-29	Ban Krabuang Yai	–	–	–	X	X	–	–
NR-B-01	Ban Prasat	22	X	X	X	X	X	?
NR-B-02	Non Prasat	1.2	–	X	X	X	–	–
NR-B-03	Ban Sa Si Liam	4.5	–	X	X	X	X	?
NR-B-04	Ban Ya Kha	13	–	?	X	X	X	X
	Walled towns							
NR-A-03	Amphoe Phimai	60	–	X	X	X	X	X
	Religious Shrines							
NR-A-01	Prasat Him Phimai	7	–	X	X	–		
NR-A-02	Meru Prahathat	0.3	–	–	X	–		
NR-A-07	Tha Nang Sa Phom	0.9	–	–	X	X		
NR-A-25	Tha Rusi	0.2	–	–	X	–		
NR-A-26	Wat Ko	1.4	–	–	–	X	–	X
	Reservoirs							
NR-A-05	Sa Phleng	4.5	–	–	X	X		
NR-A-06		–	–	–	X	X		
NR-A-24	Pratu Chay	1.3	–	X	X	X		
	Sites Outside Project Area							
NR-A-28	Ban Krabuang	3.1	–	X	X	X	X	X
NR-B-05	Ban Bing	25	–	X	X	X	X	?
NR-B-06		1	–	X	X	X	–	–
NR-B-07		0.2	–	?	X	X	–	–
NR-B-08		0.2	–	?	X	X	–	–

T = Tamyae
P = Phimai
EH = Early Historic
LH = Late Historic
* = Unable to survey
? = Probably present

Table 1. Sites of the Phimai Survey region.

EXCAVATIONS AT NON BAN KHAM AND BAN TAMYAE

From January 30 to February 15, 1980 a crew of eight laborers conducted test excavations at Non Ban Kham (NR-A-10), a 2.3 hectare, 1.6 m high, uninhabited and nearly square mound 4 km northeast of Phimai. Two 1 by 2 m test pits excavated near the center of the mound and two 1 by 1 m test pits on the south and east edges contained stratified deposits of pottery, animal bone, and shell to a depth approximately 2 m below the summit of the mound. A 1 by 1 m test pit excavated to a depth of 80 cm on a 70 cm high earth embankment on the site perimeter lacked cultural deposits.

From February 18 to May 2, 1980 a crew of eight laborers and three students from Chulalongkorn University conducted test excavations at Ban Tamyae (NR-A-11), a village 6 km west of Phimai. Ban Tamyae is a nearly circular mound, approximately 17 hectares in area (460 m in diameter), that rises 4.5 m above the surrounding plain. Most of the excavation was concentrated at the wat (monastery) on the south edge of the mound, at an elevation about 2.5 m below the summit, where surface survey had revealed heavy concentrations of sherds, including Phimai black sherds. Two 1 by 4 m trenches and a 1 by 1 m extension of one trench contained cultural deposits to 2.1 m below the surface, approximately level with the surface of the alluvial plain. On the west edge of the mound, a 1 by 4 m trench was excavated across what may be the remnants of a moat and embankment. Test pits 1 by 2 m were placed on the north and on the east side of the mound.

The first 1 by 1 m square in a trench was excavated in 10 cm arbitrary levels, except where natural or cultural layers were easily observable. Adjacent squares were opened in sequence and excavated in natural or cultural layers. All soil was screened through 6 mm screens. Soil samples for soil analysis and flotation were collected from all excavation units. A large quantity of potsherds, a few stone, bronze, iron, and non-pottery clay artifacts, animal bones, and shells of fresh water molluscs were recovered. Eight charcoal samples have been submitted for radiocarbon dating. The edges of two human burials were encountered.

Laboratory analysis continued for four months following excavation. All artifacts were examined, vessels were reconstructed, sherds from the survey and ten 1 by 1 m excavation units were analyzed, eighty 1 liter flotation samples were processed, and samples were selected for futher analysis at the University of Hawaii.

The preliminary analysis of the ceramics from Non Ban Kham and Ban Tamyae suggests that four major traditions of manufacturing pottery succeeded one another chronologically from late prehistoric to modern times. These are described below, with estimated dates for the duration of each tradition.

1. Tamyae tradition (1000-500 B.C.). These ceramics have hard, thin walls, grey, fine sand tempered paste, and gray to grayish-brown surfaces that may be plain and well smoothed, cord-marked, or decorated with impressions and fine incised straight lines or applique bands.

2. Phimai tradition (500 B.C.-A.D. 500). These ceramics, including Phimai black among other types, have a dark, gray paste tempered with rice chaff, and plain, cord-marked, or decorated surfaces. The most common decoration consists of thin polished lines burnished against a dull matte background, producing the streak polished pottery that is diagnostic of the Phimai tradition.

3. Late Historic tradition (A.D. 500-1300). These ceramics have a gray or brown paste tempered with fine to coarse sand and were almost certainly made on a wheel and kiln-fired. One ware group has orange-pink, pinkish-gray, or light brown surfaces, usually plain, occasionally incised, with a fine gritty texture, and corresponds with what is frequently termed Dvaravati pottery. A second ware group consists of the brown and green glazed stonewares and earthenwares that are called Khmer or Lopburi ceramics.

4. Recent Historic tradition (A.D. 1300-present). Modern ceramics have a brown to red paste tempered with sand or clay balls and red or yellowish-red surfaces that may be plain, cord-marked, or decorated with incised patterns. Today these are made by forming clay into rings, building the vessels from these rings, thinning the pots on a fast wheel turned by hand, and then firing the vessels in large brick kilns.

SETTLEMENT SEQUENCE IN THE PHIMAI REGION

Ceramics of the Tamyae tradition were found in the lowest cultural layers at Ban Tamyae and Non Ban Kham and in the Ban Prasat core. If earlier sites are present, the evidence is probably buried beneath the rice fields and will be difficult to discover. The makers of the Tamyae pottery appear to be the earliest inhabitants of sites that would remain as permanent settlements until the present. Because the pottery was not found on the surface at any site, the number of sites occupied at that time is uncertain.

Streak polished Phimai tradition sherds were found at Phimai and nine of the fifteen habitation mounds, and rice chaff tempered sherds without polish streaks that probably belong to this tradition were found at four other mounds. At Ban Samrit, Ban

Tamyae, Ban Prasat, and Ban Bing, Phimai tradition pottery was seen over nearly the entire extent of the mounds with deposits 1.5 to 3.0 m thick. The evidence suggests widespread occupation of the alluvial plain and intensive use of the inhabited sites for a relatively long period of time. Within the 300 km^2 survey area, at least three sites over 20 hectares (Phimai, Samrit, and Prasat), at least two sites of 13 to 17 hectares (Tamyae and Tha Luang), and five sites of 1 to 4 hectares were occupied. Probably an additional two medium-sized sites and two small sites were also occupied at this time. At Phimai the settlement expanded beyond what was probably the initial occupation on Ban Suai mound to include the area on which the temple now stands, a 30 to 40 hectare settlement.

Pottery of the early historic tradition has been found at twelve habitation sites, four of the religious shrines, the three reservoirs near Phimai, and probably at three other habitation sites. At the small sites early historic sherds are more common than Phimai sherds, and at Non Ban Kham were found in several layers. At many of the larger sites these sherds are rare and occur in only thin deposits overlying the deep Phimai tradition deposits. Whether this indicates a redistribution of the population is as yet unclear. Phimai grew into a 60 hectare town enclosed within a rectangular moat and laterite wall, at which an impressive Khmer temple was constructed. The town was far larger than any other site in the area and could have easily contained a population of 2000 to 3000 inhabitants.

There is no evidence of a discontinuity following the withdrawal of Khmer influence, and sherds of the recent historic period are found at all sites. The two uninhabited sites were abandoned during this century according to local informants, and Non Ban Kham contained several layers with recent historic sherds. A few new sites appear to have grown up along highways during this century.

SITE FORTIFICATION

The survey revealed that eight of the thirteen potential fortified mounds have earth embankments 0.4 to 1.5 m high parallel to the edges of the mounds. Four of these sites possess canals or a series of ponds along their edges, and at the other four sites rice fields, lower than the surrounding fields, are located at the mound edges. At no site did these earthworks extend beyond half the circumference of the mound, although at Ban Samrit, Ban Prasat, and Ban Tha Luang the Mun river flowed along one side of each site, and combined with canals and ponds to surround most of their circumferences.

The excavations proved of little value for interpreting the function or dating the construction of these features. The earth embankment at Non Ban Kham contained no cultural or other dateable materials. The possible moat at Ban Tamyae was underlain by at least an 80 cm deposit of seasonally saturated gleyed clay, containing very worn, chaff tempered sherds, probably of the Phimai tradition. How they became deposited in the clay is unclear.

Re-examination of the 1954 aerial photographs, used by Thiva and Srisakra, indicated that while landscape modification has destroyed some features since then, even at that time evidence for fortification of the sites was rather uncertain. Several alternative explanations may account for this lack of clear evidence of site fortification.

First, natural erosion and human activities may have levelled the landscape around the edges of the mounds, destroying evidence of former fortifications and leaving only the present remnants. The extensive landscape modifications observed during the one year of fieldwork, evidence of change since the 1954 photographs, and the descriptions of changes, including the recent filling of canals, provided by village headmen, lend support to this hypothesis.

Second, the earthworks may never have been intended as fortifications, but may have been constructed primarily for village water supplies, as first suggested by Srisakra (1970:36) and later by van Liere (1980:269). The problem of retaining water for use during the dry season is a critical one, and today ponds and reservoirs located along the edges of the village mounds are an important means for retaining water. The possible remnant fortifications may always have been canals, ponds, and reservoirs with embankments and may never have formed continuous encircling earthworks. One must also question the value of moats for defense during the dry season, the most likely time for warfare, in such a seasonally arid environment.

Finally, two different functional types of structures may, because of similarities of form, have been classified into a single category of earthwork fortifications. Many of the earthworks may have been multi-functional, but the evidence suggests a difference between sites in the alluvial plain and those in the low terrace zone and upland river valleys. Sites in the alluvial plain, except Phimai and perhaps a few other large sites, may have simply possessed tanks and canals for water supplies, and these have been mistaken for defensive earthworks. Sites in the low terrace zone and upland river valleys, where rice land is scarce, settlements isolated, and defense perhaps more necessary, have more massive and complete earthworks and may have been true fortified sites. These hypotheses can be tested with further research.

PREHISTORIC AGRICULTURE

The relative stability of the settlement pattern from the time of the Phimai and perhaps the Tamyae tradition until the present, when rice agriculture is the primary occupation of all villagers, may be an indication of continuity in subsistence practices. The use of rice chaff as the primary temper in Phimai tradition pottery also suggests that rice was being cultivated at that time as the major food crop. The distribution of sites is clearly correlated with the availability of land suitable for rice cultivation. Within the survey area, most of the land is of this type, and sites are distributed fairly evenly across the floodplain. No sites have been found in the uplands, but intensive survey has not yet been undertaken. Within a 30 km radius of Phimai, all probable prehistoric and early historic sites identifiable from aerial photographs have at least 500 hectares (about 40% of the total land area) within a 2 km radius suitable for rice cultivation. Where land suitable for rice agriculture is rare, most sites are located on non-cultivable land adjacent to rice fields.

No agricultural tools were recovered in the excavations. Fragments of iron tools were recovered from a layer transitional between the Tamyae and Phimai traditions at Ban Tamyae, so iron would have at least been available for plowshares by that time. The only floral remains recovered, even after flotation, were wood charcoal, the rice chaff used for tempering pottery, and occasional rice grain impressions on potsherds. Reservoirs are almost always located adjacent to habitation sites and probably served mainly as tanks for domestic water supplies. There is no evidence of canal systems associated with them, and, if former canal systems did exist, these have been obscured by more recent agricultural field systems and could not be identified.

INTERREGIONAL EXCHANGE

The ceramic remains provide evidence of a growing volume of trade over time with areas outside the Phimai region and increasing distances over which trade was conducted. The Tamyae tradition represents a unique cluster of elements and appears, on present evidence, to be confined to the Phimai region itself. The Phimai tradition is a widespread regional tradition, found throughout the upper Mun river valley, but not in the middle Mun river basin or the upper Chi river valley. The presence of a few sherds at Chansen (Bronson 1976:389-391) suggests trade contacts between central Thailand and the Phimai region. A few sherds of a thin, white ware found at Ban Tamyae and Non Ban Kham may be related to the white wares from Non Nok Tha and the Roi Et sites. The gritty, sand tempered wares of the early historic tradition are very similar to the "Se type complex" from phases V and VI at Chansen (Bronson 1976) and to the "Dvaravati pottery" found at sites throughout central and northeast Thailand. This similarity over a wide area suggests manufacture in a limited number of specialized centers sharing basic manufacturing techniques and distribution from these centers. The Lopburi wares were probably manufactured at a few kiln sites and then traded throughout the area under Khmer control. During the recent historic period, ceramic manufacture probably became more localized again, but certain wares were imported into the Phimai region from even greater distances than previously. Sukothai style celadons, probably from north Thailand, and Chinese porcelains are found at numerous sites. During the present century local production of pottery ceased and pottery is manufactured at a few specialized centers in villages southeast of Khorat.

The few bronze bracelets and fragmentary pieces found in Phimai tradition and later layers indicate that the Phimai region was part of the network for the exchange of bronze and the metals used in its manufacture. The iron slag at Phimai is evidence of local iron working, perhaps of iron from laterite sources in the uplands. Salt is currently being mined from the Kula Ronghai and Phimai soils. Salt and iron may have been exported from the Phimai region during prehistoric times, but there is as yet no archaeological evidence to verify this.

PRELIMINARY INTERPRETATIONS

At the time of the Tamyae tradition, settlements were established in the alluvial plain of the Phimai region, probably supported by rice agriculture, with local production of ceramics and exploitation of local shell resources. During the period of the Phimai tradition, settlements were present throughout the alluvial plain in a pattern that has remained essentially the same throughout the historic period. Rice was cultivated as the primary subsistence crop, iron tools were manufactured, and bronze and other items were traded in an interregional exchange network. A distinctive regional ceramic style characterized the pottery of the upper Mun river valley, and Phimai black wares were probably being manufactured in a few specialised centers. The presence of three settlements over 20 hectares and of size ranking of sites may indicate a hierarchical political structure. While requiring more substantiation, it is plausible to hypothesize that during the period of the Phimai ceramic tradition a complex political and economic system became established in the Phimai region. Specialized production of some goods, intraregional and interregional exchange systems, and a hierarchical political structure for which there is clear evidence during the early historic period probably already existed during the late prehistoric period.

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REFERENCES

Bronson, Bennet. 1976. Excavations at Chansen and the cultural chronology of protohistoric central Thailand. Unpublished Ph.D. Dissertation, University of Pennsylvania.

FAD. See Thailand Fine Arts Department.

Groslier, Bernard P. 1963. Karn Sorm Prasat Hin Phimai. (The reconstruction of the Phimai Temple.) Translated into Thai by Subhadradis Diskul. Fine Arts Department, Bangkok.

Higham, Charles F.W. 1977. The prehistory of the southern Khorat Plateau, North East Thailand, with particular reference to Roi Et Province. In Modern Quaternary Research in Southeast Asia. 3:103-142.

Higham, Charles F.W. and R.H. Parker. 1970. Prehistoric investigations in N.E. Thailand 1969-1970: preliminary report. University of Otago, Dunedin.

Liere, W.J. van. 1980. Traditional water management in the Lower Mekong Basin. World Archaeology. 11:265-280.

Parker, R.H. 1966. Excavations at Pimai: preliminary report. In Preliminary reports on excavations at Ban Nadi, Ban Sao Lao, Pimai No. 1 (ed. W.G. Solheim II). Mimeographed, University of Hawaii, Honolulu.

Solheim II, Wilhelm G. 1965. A preliminary report on a new pottery complex in northeastern Thailand. In Felicitation volumes of Southeast Asian studies II, p. 249-254. The Siam Society, Bangkok.

Solheim II, Wilhelm G. and Marti Ayres. 1979. The late prehistoric and early historic pottery of the Khorat Plateau, with special reference to Phimai. In Early South East Asia (eds R.B. Smith and W. Watson), p. 63-74. Oxford University Press, London.

Srisakra Vallibhotama. 1970. Review of Dvaravati: the earliest kingdom of Siam by H.G. Quaritch Wales. Journal of the Siam Society. 58, Part 1:126-136.

Subhadradis Diskul. 1956. Muang Fa Daed, an ancient town in N.E. Thailand. Artibus Asiae. 19:362-367.

Thailand Fine Arts Department. 1959. Plan and report of the survey and excavations of ancient monuments in Northeastern Thailand. Fine Arts Department, Bangkok.

Thiva Supajanya and Srisakra Vallibhotama. 1972. The need for an inventory of ancient sites for anthropological research in Northeastern Thailand. Tonan Ajia Kenkyu (Southeast Asian Studies). 10:284-297.

Wales, H.G. Quaritch. 1957. An early Buddhist civilization in Eastern Siam. Antiquity. 31:42-50.

-------------------- 1969. Dvaravati: the earliest kingdom of Siam. Bernard Quaritch, London.

Williams-Hunt, P.D.R. 1950. Irregular earthworks in eastern Siam: an air survey. Antiquity. 24:30-36.

NEW PERSPECTIVES ON INDO-MALAYSIAN PREHISTORY

Peter Bellwood
Australian National University

The following paper is extracted from a presidential address given to Section 25A (Archaeology) at the 53rd ANZAAS Congress, held in Perth, Western Australia, in May 1983. The text has not been changed from the cyclostyled version which was originally distributed at the Congress, although I have deleted the general introductory statement.

THE SHAPE OF INDO-MALAYSIAN PREHISTORY

In the time allowed for a short address I cannot hope to discuss all the major themes in Asian prehistory which from time to time attract my attention. Instead, I will concentrate on the area which has interested me most during the past ten years - Island Southeast Asia (or the Indo-Malaysian archipelago) - through a time-span is taken up by the expansion of the Austronesian-speaking peoples, who today number some 220 million souls in perhaps 100 or more major ethnolinguistic groups. The story here is not just an archaeological record, but involves very careful consideration of linguistic, biological and anthropological data, as well as results from the natural and earth sciences. At present I am completing a book on Indo-Malaysian prehistory, a much-revised and expanded version of a part of my Man's conquest of the Pacific which was published in 1978. Since then I have written three general "updates" of my views (1980a; 1980b; 1983a), but here I wish only to be discursive and to give impressions.

Some of the major questions which attract my interest in this archipelago are as follows:

(1) The time and space developmental histories of major ethnolinguistic groups - the Austronesians, and more peripherally the Aslian peoples of Malaya and the Papuans of New Guinea.

(2) Major aspects of the interrelationships between the main ethnolinguistic groups - for instance, the whole question of biological and ethnolinguistic "diversity" in eastern Indonesia and Melanesia is, to my mind, very closely related to the nature of two-way relationships between long-resident Papuan groups and expanding Austronesian populations.

(3) Major aspects of prehistoric developments in technology and economy - many questions arise here, such as the role of the hitherto ignored but clearly dramatic change to

Holocene climatic conditions; the patterning of different stone tool industries; the origins of agriculture; the significance of cereal agriculture as an initial trigger for Austronesian expansion; and the later equatorial economic adaptations of the Austronesians.

I have views on all these questions, which I will now try to summarize.

Firstly, it is very important to set out some fundamental facts about the Indo-Malaysian archipelago in terms of its geographical shape, its climates and, since I will be considering agricultural populations, its soils. I always view geographical shape in terms of an upside-down T (as seen looking north from Australia). The north-south stem of the T is formed by Taiwan and the Philippines, and it meets the west-east bar in Sulawesi. This bar is in fact double - the great equatorial islands of Sumatra, the Malay Peninsula, Borneo and Sulawesi form one bar which ends in the Moluccas; and the much thinner Sunda chain from Java eastwards forms the other. Both converge towards the east to meet in New Guinea.

In terms of climate and soils we have a most fortunate concurrence which I believe is absolutely crucial in considering all prehistoric periods, right back to Homo erectus. The equatorial islands are in general constantly humid, lack dry seasons, and support dense evergreen equatorial forest on infertile leached soils. The intermediate tropical islands (i.e. parts of the Philippines and the central-eastern Sundas) tend to have long dry seasons, fertile volcanic soils in many places (especially Java and Bali), and support a more open forest and even grasslands in very dry areas (I am referring to natural vegetation here). Beyond the intermediate tropical zone lie the subtropics of southern China and Australia.

It seems to me that throughout human prehistory in Southeast Asia the intermediate tropics have always been much more significant than the equatorial zone (of the subtropics of the northern hemisphere and their central role in agricultural origins I will speak later). Certainly, in terms of modern population distribution and agricultural potential the distinction is crystal clear - compare the 80 million inhabitants of Java with the 5 million of much larger Indonesian Borneo. Since almost all Austronesians have been agriculturalists during the 5000 years of their existence in Island Southeast Asia this observation is highly significant. But I think it also applies to the remoter past. Ever-wet equatorial rainforest is not a favourable environment for hunter-gatherers, although they can survive there in small bands. I suspect, although I find it hard to prove, that the more open monsoonal forests and parklands of parts of the Philippines and the

Sundas from Java eastwards would have supported in pre-agricultural times (and especially in the late Pleistocene) a greater mammal biomass than the equatorial forests, although faunal diminution across Huxley's Line may have reduced the differences in eastern Indonesia. Despite the rather special conditions for fossilization in Java, it is perhaps no coincidence that the remains of *Homo erectus* have been found in several places there, and yet remain unrecorded in Sumatra and Borneo - even the rather meagre evidence of stone tools seems to be in support of this distribution.

1. Pre-Austronesian (ca. 20,000-5000 B.P.)

Let us first consider the human situation in the Indo-Malaysian archipelago at about 18,000 years ago - at the peak of the last glaciation. Firstly, sea levels were lower, and the two continental shelves of Sunda and Sahul were exposed, with the Wallacean islands between. The latter, of course, were never land-bridged. World climates were generally cooler and drier than they are now, and although we know little about climatic conditions in the Indo-Malaysian equatorial belt - opinions differ on the magnitude of any differences from present conditions which might have existed - we do know that the intermediate tropical belts were drier and probably supported a more open vegetation than they do now. In fact, hunting and gathering may have been a very flourishing lifestyle in those regions at that time; in the north with mobile cognatic bands of Negritos and related groups, and in the south with groups related to the peoples of New Guinea and Australia, with strongly patrilineal group organizations and sharp distinctions between male and female ritual statuses. I suspect that the equatorial region was only very thinly inhabited, except in favourable coastal, lake-edge or riverine situations.

Let us now consider the situation about 8000 years ago, towards the end of the late glacial climatic amelioration, and at a time when the sea had almost reached its present level. By this time the archipelago had taken on its familiar shape of many islands, and climates were a little warmer and wetter than at 18,000 years ago; the equatorial rainforest may have expanded slightly, and the creation of new water barriers combined with human predation may have caused a limited number of mammal species to become extinct. Evidence is a little unclear on this, as it is in Australia, but two important species which do disappear at about this time are the Javan rhino in Borneo and the elephant in Java.

From my reading of a range of recent articles on palaeoclimatology, in which a variety of information sources (oxygen isotopes, carbon-13, ocean salinity, pollen and past sea-levels) have been used, I have little choice but to believe that the climatic amelioration which occurred between about 14,000 and 8000 years ago was of an order of magnitude far in excess of anything which had occurred in the previous 100,000 years (see Kukla 1981; Fig. 4 for illustration). I think we need to sit back and allow the significance of this observation to sink in.

In recent years I have come more and more to doubt the idea that early Holocene populations in various parts of the world developed agricultural techniques purely by chance, with no common factor of causation. Of course, diffusion in its most simplistic form is not the answer. But I now believe that the dramatic nature of this warming of the earth, and of the spread of forests and cereals from their more restricted glacial distributions, gave unparalleled advantages to certain populations in a specific latitudinal belt. This belt lies between approximately 20° and 40° north, and it includes the homes of cereal domestication in western Asia (wheat, barley), central China (some millets), southern China and northern Southeast Asia (rice), and highland Mexico (maize). It now seems to me, as it has seemed to many before me, that agricultural developments based on cereal cultivation in these regions led to fundamental changes in the nature of human society; they have ultimately transformed the face of the earth.

Island Southeast Asia is, of course, a long way below this latitudinal belt, and has clearly not contributed to the origins of cereal cultivation. But what of those hoary old theories that people here were busily cultivating tubers and fruits while others were still hunting and gathering everywhere else? I must say now, after some years of considering this question, that I can see no indication whatsoever that such a stage existed anywhere in Southeast Asia (for New Guinea see below). The basic techniques of agriculture (or horticulture if we need to split hairs) were introduced by Austronesian-speakers from the cereal belt far to the north, after 5000 B.P..

I know that this kind of statement is guaranteed to generate criticism, but my viewpoint is basically this. Of course forest hunters and collectors have always re-planted tuber tops, exploited fruits, dropped seeds around their campsites, and so forth. I am also sure that many of the major plants now domesticated which are of Indo-Malaysian or Oceanic origin - bananas, coconuts, breadfruit, varieties of yams and aroids - have been intensively collected since humans have inhabited the region. But I really don't believe that these practices have much to do with a systematic seasonal round of forest clearance, planting, weeding, and harvesting on an annual basis. I strongly suspect that, as far as Island Southeast Asia is concerned (and not necessarily New Guinea), this economic mode has its origins in the regions of seasonal cereal cultivation, and that the local tubers and fruits were adopted into the system, and the cereals dropped out of the system, as Austronesians expanded towards the Pacific Islands.

I wish to make another point. In the past, I and many other prehistorians have adopted the idea, originally derived from the writings of Boserup, that the post-glacial sea-level rise in Southeast Asia caused demographic crowding and hence stimulated agricultural developments. I no longer regard this view as having any real validity. For one thing, the coasts of the Sunda continent would have been so low-lying and swampy that they could only have supported very small populations willing to survive on shellfish and other products of a mangrove environment. Furthermore, and perhaps more importantly, as the sea-level rose the extent of coastline eventually increased rather than decreased. It may be that the drowning of the great Sunda continent took place totally unnoticed by the many generations of inhabitants who "witnessed" the event.

The basic view which I am adopting here is that the late glacial climatic amelioration, despite its importance in certain latitudes, had relatively little impact on human society in Island Southeast Asia, although I do not deny that environmental changes here did change the whole geographical face of the archipelago. The archaeological evidence presents certain faces which do not really contradict this view - the Hoabinhian in Malaya lasts to about 3000 years ago in the interior, and in northern Borneo an industry of horsehoof and discoid cores, rather amorphous flakes and scrapers, and occasional grindstones and bone tools continues with apparently little change from the late Pleistocene until the period of Austronesian settlement. In fact, Borneo, the Philippines and some parts of eastern Indonesia have now produced many assemblages from late Pleistocene and early Holocene contexts which seem to be quite closely related to the "core and scraper" industries of Australia and New Guinea.

However, it is always dangerous to over-generalize. I am saying that there are no apparent signs of any change in a basic hunting and gathering economy in the Indo-Malaysian archipelago until perhaps 5000 years ago or later, and I am also saying that some aspects of stone tool technology express long-term stability. But there are at least three pieces of evidence which, in different ways, serve to challenge our impressions of uniformity. Firstly, I will refer to the research by my colleague Jack Golson and his team in the Wahgi valley in the Papua New Guinea Highlands. Here, it does appear that agricultural techniques developed independently, after about 9000 years ago, in the rather unique environmental conditions of the highlands which, incidentally, have no real analogues in the islands of Southeast Asia. I think this evidence throws a whole new light on Papuan prehistory, and I will return to this matter later on.

Secondly, two recent discoveries from the period between 20,000 and 30,000 years ago challenge the apparent stability of the stone tool traditions of the Indo-Malaysian archipelago. Ian Glover

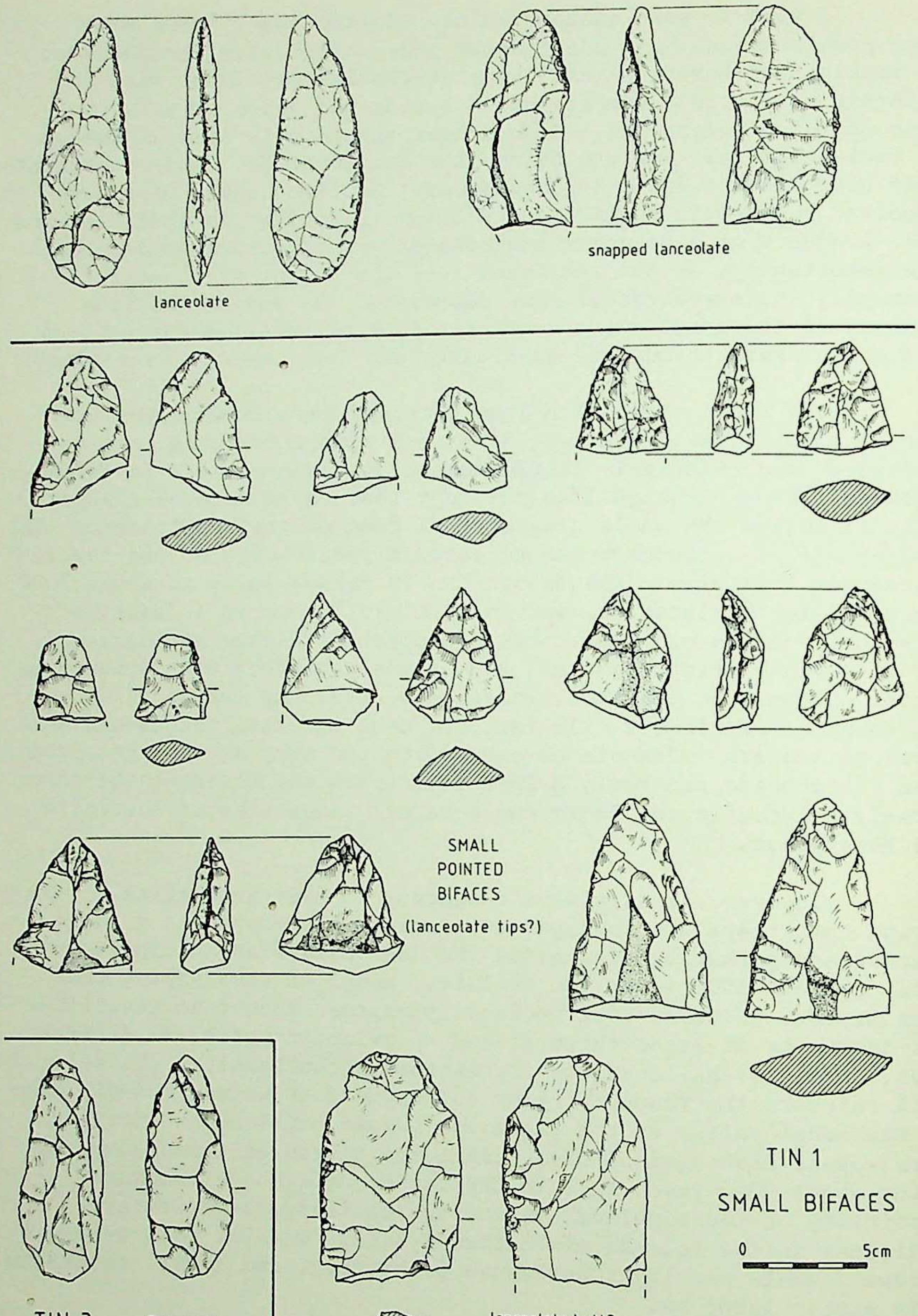

Figure 1. Bifacial Lanceolates from Lake Tingkayu.

(1981) has reported an industry of elongated flakes struck with prepared striking platforms from the cave of Leang Burung 2 in southern Sulawesi - an industry which has certain affinities with the Old World Levalloisian technique. A Sabah Museum team (Bellwood 1983b) has also reported a quite unique industry of bifacially-flaked lanceolate knives (Fig. 1) from a site on the shoreline of a 100 km^2 late Pleistocene lake (Lake Tingkayu) in eastern Sabah; this industry, which is associated with a flake and not a blade component, is believed to date to about 20,000 years ago.* It has certain parallels in Japan and north-eastern Asia, but I am unwilling to be specific about these at present.

Thirdly, we have the well-known occurrence of blade-like flake industries after perhaps 7000 years ago in the Philippines, Sulawesi, and possibly Java, with an interesting elaboration of backed flakes and microliths in the Toalian of southern Sulawesi. I am now fairly certain that industries of this type do not occur in Borneo or Sundaland generally (with the possible exception of Java), and they also appear to be absent in far eastern Indonesia and New Guinea. I would be willing, given their apparent restriction to a north-south distribution through Sulawesi and the Philippines, to consider a case for diffusion of technique from Japan. However, I hesitate to enter the debate about the origin of the "small-tool" industries of Australia - I am aware that there is now a trend towards regarding them as indigenous creations, although I should point out that Gollan (1983) suggests that the dingo may have an Indian origin, and also that the southern and eastern states of India (Kerala, Tamil Nadu, Andhra Pradesh and Orissa) have so-called "non-geometric" microlithic industries which I feel are morphologically quite close to some Australian industries. Unfortunately, the Indian Ocean is rather wide, and microlithic industries do not occur on the mainland of Southeast Asia or in Sumatra, so I am still inclined to think that the closer central Indonesian occurrences may be more relevant for those who wish to make a case for introduction.

2. Austronesian expansion, after 5000 B.P.

The Indo-Malaysian archipelago at 5000 years ago appears, therefore, to have been occupied by hunting and gathering societies with fairly uniform flake industries (excluding the Toalian and a few other more northerly pockets), and with population densities perhaps highest in the areas with long dry seasons outside the equatorial zone. Between 5000 and 3000 years ago the major phenomenon of Austronesian expansion changed the whole face of the region.

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* See Addendum.

I now need to make some generalizations for which I can produce detailed support, but not in the context of this short paper. Firstly, I am not prepared to accept that the predominantly Southern Mongoloid inhabitants of Island Southeast Asia have evolved within that region, apart from the micro-evolution which has occurred since their expansion took place. Secondly, I accept the results of an enormous quantity of linguistic research which suggests that early Austronesians were agriculturalists with cereal (rice and millet) cultivation, canoes, timber houses, pottery, domestic animals (pigs, dogs and possibly chickens), and, in short, many of the features of an agricultural neolithic lifestyle (see Blust 1976; Foley 1980 for brief statements). The Austronesian languages have their origins in the region of southern China and Taiwan, and I refuse to believe that they have spread through the Indo-Malaysian archipelago by anything short of a major expansion of their speakers accompanied by assimilation of pre-existing non-Austronesian groups.

The combined results of many years of research by comparative linguists (Kern, Dempwolff, Haudricourt, Benedict, Blust and many others) now suggests that the expansion of Austronesian speakers took place from Taiwan, southwards through the Philippines, and then westwards to Malaya and eastwards to Polynesia. Without going into all the details of proto-languages and "family-trees" I will just make two further points; there is not the slightest degree of evidence to suggest that Austronesian expansion took place through Malaya or from the coasts of Vietnam, and the lexicostatistical classification of Dyen, which Melanesianists have often adopted with great gusto, is in part a classification of retention rates in vocabulary from Proto-Austronesian, and not truly a genetic classification. These retention rates (or rates of vocabulary change) are known to vary so much from region to region that overall lexicostatistical classifications and the glottochronological dates derived from them give results which are way out of line with all other sources of data on Austronesian prehistory. The linguistic diversity in Melanesia has arisen owing to very rapid rates of change caused by influence and assimilation between small-scale Papuan and Austronesian-speaking groups over a period of some 3500 years. The actual date of Austronesian expansion into western Melanesia now appears to be only about 4000 years ago or less, and not the dates in excess of 5000 years which others, including myself, have accepted in the past. The spread and break-up of Proto-Oceanic (Pawley 1981) is almost certainly to be associated with nothing less than the expansion of the Lapita culture through Melanesia into western Polynesia.

I am of course hinting here at linguistic models which many prehistorians may find exasperating and very hard to equate with the archaeological record. It is my belief that, as far as the prehistory of the Austronesian-speaking peoples is concerned, the

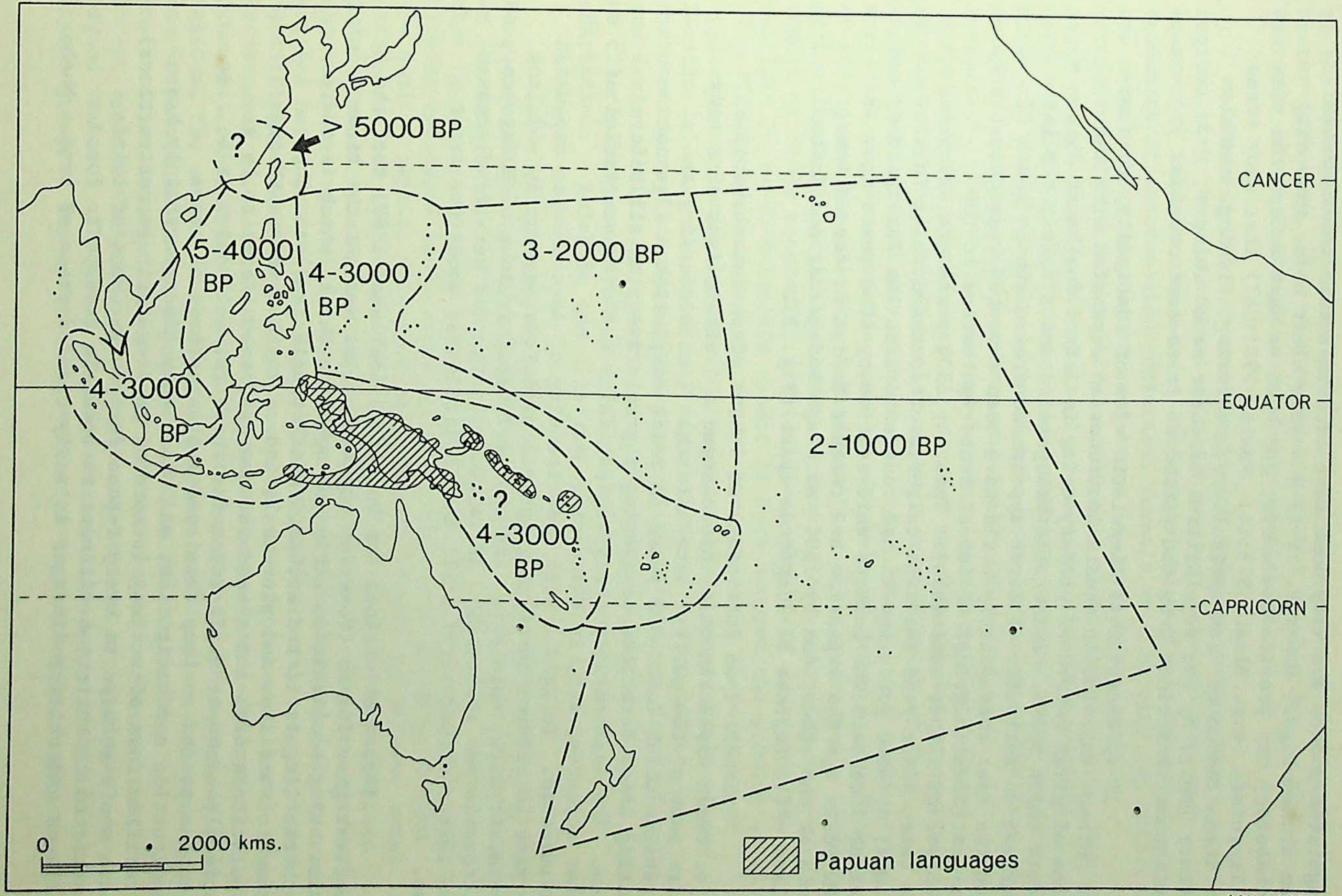


Figure 2. The Expansion of Austronesian Settlement.

ANU 1983

linguistic models are very much more important than those derived from archaeology. However, it is now very clear to me that only archaeology can provide the dates, and here we must accept the view of linguists (e.g. Blust 1976:24; Pawley 1981:287) that many terms for items connected with agriculture, seafaring, fishing, and also pottery imply, by the regularities of their sound changes, continuous traditions from the period of Proto-Austronesian.

If we accept this linguistic view of continuity, then we are perhaps entitled to equate Austronesian expansion with the archaeological record of pottery-using in Island Southeast Asia - a record which shows considerable homogeneity and a fairly regular decrease in antiquity of first appearance from north to south (I find the idea that pottery could have been invented independently by non-Austronesian groups of forest hunter-gatherers in the archipelago rather untenable). Thus, by 5500 years ago expansion had taken place from the rice cultures of southern China into Taiwan, by 5000 years ago it had continued into the Philippines, and central Indonesia was perhaps well-settled by 4000 years ago. By 3000 years ago the expansion had reached Malaya at one extreme, Samoa at the other, and by 1500 years ago Madagascar and Easter Island - 210 degrees of longitude apart (Fig. 2).

So here I am inferring, as I have often done before, a major human expansion which has changed the ethnic face of a very large part of the earth. Note here that I am discussing an expansion which took 4000 years to reach completion; I am not talking about ferocious conquering migrants sweeping all before them. The Austronesian story was partially one of assimilation of other cultures, and, in Melanesia, partially one of being assimilated. To gain a real understanding of Austronesian expansion we need to examine three geographical divisions separately - Island Southeast Asia, Melanesia, and the peripheral regions of Madagascar, Micronesia and Polynesia. It is not my intention here to discuss the latter areas, but I still have a little say about the first two.

I have maintained for some time (Bellwood 1980) that the source-region for Austronesian expansion lies amongst the rice-cultivating neolithic societies of southern China, which is where both the linguistic and archaeological trails lead us. The expansion was slow and piecemeal, and an initial source through population growth and a need for new land seems to me to be a perfectly adequate explanation for the first millennium or so. As groups expanded so they developed better methods of canoe construction and navigation, and since they almost certainly had a stratified form of society (according to linguistic reconstructions) there would perhaps be every reason for younger sons of chiefs, restricted in their inheritances at home, to attempt to found villages and chiefly lineages in newly-cleared areas of land. Much of the resultant expansion involved co-existence with aboriginal hunter-gatherers, many of whom have survived to this day as the Negritos of the Philippines and later-settled Malaya.

The initial southward expansion from the sub-tropical regions with their monsoonal climatic regimes into the ever-wet equatorial islands also caused fundamental adaptations in the economies of Austronesian societies. Cereals such as rice and millet are annual crops adapted to variations in day-length, sunshine intensity and rainfall in the latitudes of their origin. Rice, for instance, grows best in sub-tropical climates with high sunshine duration and low cloud-cover. In equatorial regions these cereals, while not totally unsuited, would have lost dominance in the face of the more suitable native tubers and fruits of the region. Furthermore, forest cutting and burning, to say nothing of weed control, is not at all easy in a dense, massive and wet equatorial rainforest without metal tools, as the recent history of Iban expansion in Sarawak may perhaps tell us. Indeed, some Austronesian societies of these regions, such as the Kubu of Sumatra, the Penan of Borneo and the Tasaday of Mindanao have clearly dropped a former agricultural lifestyle in favour of hunting and gathering.As a result of these equatorial difficulties, the first Austronesian settlers to reach Melanesia appear to have dropped the growing of rice altogether, and to have turned completely to the economy of vegetative reproduction of fruits and tubers characteristic of the Pacific Islands. In addition, if populations in New Guinea and surrounding regions were already practising their own forms of tuber and fruit cultivation, as the emerging record seems to suggest, then we clearly have scope for borrowing as well as ecological adaptation.

But economy was not the only aspect of Austronesian life to have changed deeply as expansion progressed. In the Philippines and in the equatorial islands such as Borneo and Sulawesi it appears that loosely stratified forms of cognatic social organization, often without corporate land-owning descent groups greater in size than the nuclear family, were able to establish themselves without undue influence from any populations there before. But in south-eastern Indonesia and Melanesia (I am not so certain about Sumatra and Java) the story was very different. Large Papuan-speaking populations existed here, possibly with pre-existing agricultural economies and certainly with social structures centred on corporate unilineal (presumably patrilineal) descent groups focussed on localized lineages. As anyone who knows the ethnography of these regions will realize, the assimilatory process between Austronesian and Papuan was very much a two-way phenomenon, and in Melanesia the Austronesian "energy" can be said to have virtually petered out, except amongst those who reached the uninhabited archipelagoes beyond Vanuatu. The great significance of this long-lived and stable group of Papuan-speaking societies in the border regions between Indonesia and remote Oceania has perhaps not yet been realized to its full due.

I am fully aware that in this paper I have been presenting some wide-ranging views which have wide implications for prehistoric interpretation in what is, after all, a very large area of Southeast Asia and the western Pacific. I am always happy to be proven to be wrong on some topics if new data so demand, and I am happy to modify my ideas as necessary. Perhaps I can finish by mentioning three rather important lacunae in the prehistory of the region which we need to examine with some urgency. We do need to find out much more about the prehistory of rice cultivation in the region between the Ganga valley and southern coastal China. We do need (for reasons not really touched on in this paper) to know a lot more about the prehistory of Java and Sumatra. And finally, we must find out more about the extent of the agricultural knowledge of people in the New Guinea region prior to Austronesian settlement.

REFERENCES

Bellwood, Peter. 1978. Man's conquest of the Pacific. Auckland: Collins.

-------------- 1980a. Plants, climate and people: the early horticultural prehistory of Indonesia. In Indonesia: the making of a culture (ed. J.J. Fox), pp.57-74. Canberra: Research School of Pacific Studies.

-------------- 1980b. The peopling of the Pacific. Scientific American. Vol. 243, part 5:174-85.

-------------- 1983a. The great Pacific migration. Yearbook of Science and the future (Encyclopaedia Britannica), in press.

-------------- 1983b. Archaeological research in the Madai-Baturong region, Sabah. Sabah Museum Annals, in press.

Blust, Robert. 1976. Austronesian culture history: some linguistic linguistic inferences and their relations to the archaeological record. World Archaeology. 8:19-43.

Foley, W.A. 1980. History of migrations in Indonesia as seen by a a linguist. In Indonesia: the making of a culture (ed. J.J. Fox), pp.75-80. Canberra: Research School of Pacific Studies.

Glover, I.C. 1981. Leang Burung 2: an Upper Palaeolithic rock shelter in South Sulawesi, Indonesia. Modern Quaternary Research in Southeast Asia. 6:1-38.

Gollan, Klim 1983. Prehistoric dogs in Australia: an Indian origin? In Recent advances in Indo-Pacific prehistory (eds V.N. Misra and Peter Bellwood). New Delhi: Oxford-IBH (in press).

Kukla, G. 1981. Pleistocene climates on land. In Climatic variations and variability: facts and theories (ed. A. Berger), pp.207-32. Dordrecht: D. Reidel.

Pawley, A.K. 1981. Melanesian diversity and Polynesian homogeneity: a unified explanation for language. In Studies in Pacific languages and cultures (eds J. Hollyman and A.K. Pawley), pp.269-309. Auckland: Linguistic Society of New Zealand.

ADDENDUM (August 1983)

A recent radiocarbon result provided by the ANU Laboratory suggests that the Tingkayu industry from Sabah may be closer to 30,000 years old. The sample is of charcoal burnt beneath a lava flow near Tingkayu village which flowed across the surface of the presumed lake sediments at a time when they were clearly dry and supporting vegetation. The date is 28,300 ± 750 (ANU 3444 - coarse fraction), and geomorphic information suggests that the lake had already drained away by this time. The full argument is being prepared for publication.

PRELIMINARY REPORT OF EXCAVATIONS AT NOMBE ROCKSHELTER, SIMBU PROVINCE, PAPUA NEW GUINEA

Mary-Jane Mountain
Australian National University

HISTORY OF EXCAVATION

Excavation began at this site in 1964 during the fieldwork of J.P.White (published as NIOBE in White 1972). Considerable stratigraphic complexity persuaded him to divide the finds into only two broad groups: that above substantial sheets of flowstone, and that from below and outside (to the east) of those sheets. White's work had produced large amounts of animal bone and stone, but detailed analysis and dating were not possible without further understanding of the stratigraphy. The present researcher was directed towards Nombe and other sites in the Kundiawa/Chuave area, in what was then the Chimbu District, in 1971 (Figure 1). The aim at that time was to investigate further some complex but potentially interesting sites. The research was intended to take only a short time. The aim of the work at Nombe in 1971 was to test another area of the site to see whether more sense could be made of the stratigraphy and chronology in order to allow further analysis of a potentially interesting and productive site.

New excavations by the author in late 1971 revealed a depth of Pleistocene deposits, under the base of White's excavations, that contained considerable amounts of both animal bone (including extinct fauna) and stone artifacts. Even larger quantities of more recent materials were also recovered but the stratigraphy seemed to have little connection with that shown in White's excavation drawings of 1964.

The author then became based in Port Moresby, but teaching and administrative duties at the University of Papua New Guinea prevented much progress being made on the detailed analysis of the large quantity of material. Further fieldwork and excavation was undertaken with students in 1974/5. By 1979 the author had become a Ph.D. student and the final phase of fieldwork was undertaken in 1979/80. The aim of the work by this time was to explore the impact that was made on the Elimbari region by the combined actions of human and animal predators and natural forces of change, especially during the Late Pleistocene and early Holocene periods. This report summarises the work to date (May 1983). Further analysis will facilitate the complete publication of this rich, interesting and complex site and area.

Relationship to other archaeological sites within the highlands(Figure 1)

The number of sites (both open and caves or rock shelters) that have been examined for archaeological evidence in the central highlands of Papua New Guinea is growing steadily (i.e. P.Gorecki,

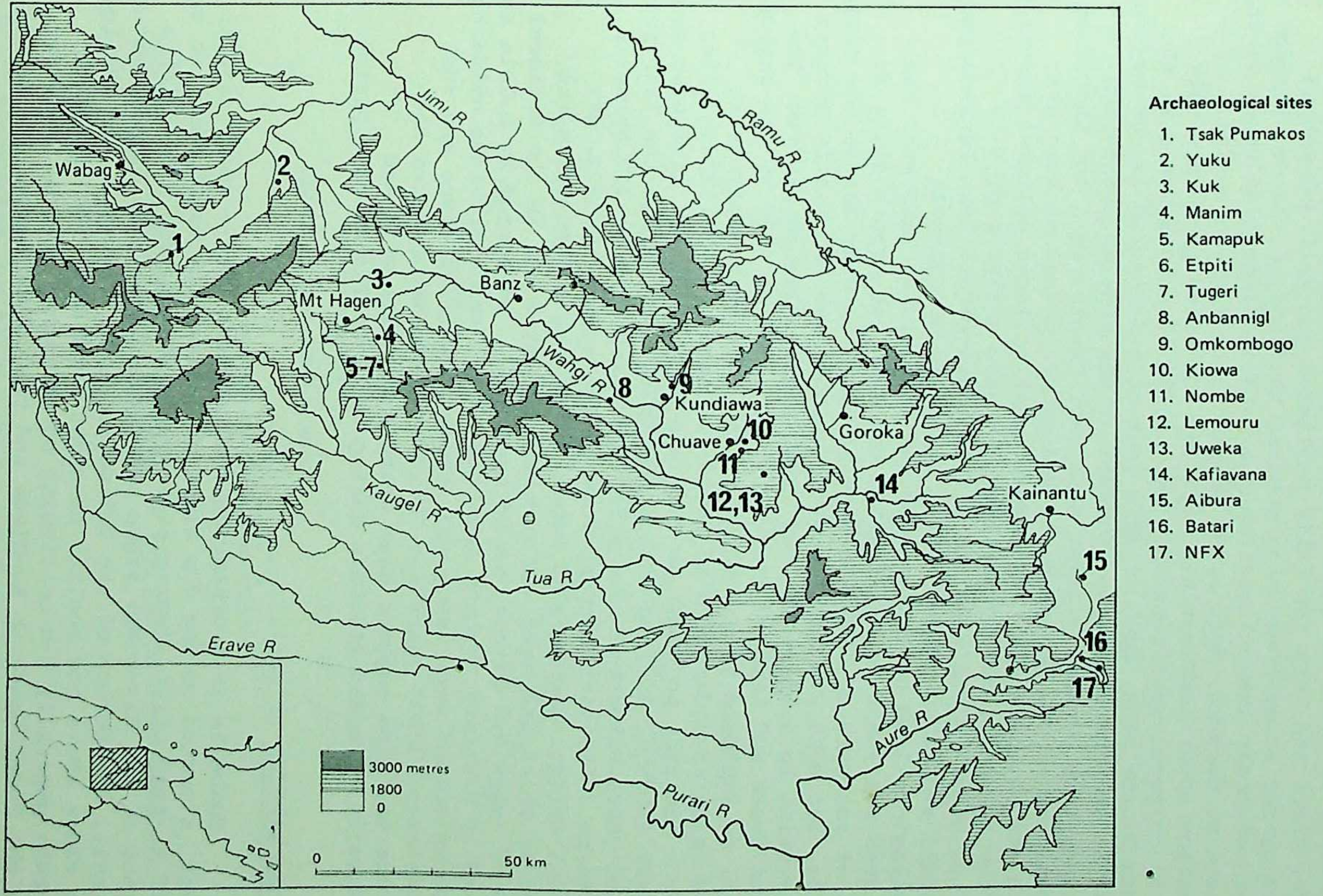


Figure 1. Archaeological Sites in the Central Highlands of Papua New Guinea. (Nombe is No. 11)

Dept. of Prehistory, R.S.Pac.S., A.N.U.) is at present excavating in the vicinity of the Jimi river valley, Western Highlands Province). However, there are very few fully published and well documented archaeological sites from which general theories of the development of human economic and cultural change, and the impact of these on the area, can be deduced. Most sites contain little or no useful information about sediment history, and too often there are only lists of cultural artifacts which cannot be closely related to the deposits of the site. Much of this lack of information is, of course, due to the standards that were normal at the time of excavation. Techniques have changed a great deal over twenty years and increased understanding of the processes of sedimentation and erosion has changed the way in which the archaeologist collects cultural material and often needs to solicit assistance in the analysis of site deposits. Figure 1 includes two little known sites (Tsak Pumakos and Anbannigl) excavated in the 1960's by a team of Japanese archaeologists lead by T.Kobayashi and J.Hayakawa. This work has never been published in English and the Japanese report gives no detail of analysis of data.The site of Kiowa is only 3km to the north of Nombe, but both J.P.White and the author have had little success in attempting to compare the two sites from published records. The sites of Uweka and Lemouru were both excavated in 1979 by the author and will be included in the final report. Sediment analysis at Lemouru is being undertaken by David Gillieson (1983). These sites provide a contrast to Nombe as they are both at higher altitudes and are small sites of limited occupation span, used within the last few thousand years.Omkombogo is a site first excavated by J.P.White in 1964 (White 1967) with further work by the author in 1971. NFX (National Antiquities File of Papua New Guinea registration,the records of which are held and administered by staff in the National Museum of Papua New Guinea) is an open site, excavated by D.Cole and analysed by V.Watson (Watson and Cole 1978), which provides evidence that human beings were using open sites as well as caves and rock shelters about 18000 years ago. Evidence from Yuku, Kiowa and Kafiavana may also suggest that these sites were utilised periodically by human visitors during the Late Pleistocene period.

SITE DESCRIPTION (Figure2)

Nombe is an overhanging rock shelter with a small cave at the rear, situated on the dip slope of a limestone escarpment, at the foot of a steep cliff, facing east over a deep doline into which a tributary of the River Mai sinks underground. The site lies at about 1720m.asl., the bottom of the doline at about 1660m.asl, and the top of the ridge above the shelter at about 1950m.asl. The limestone ridge runs generally S-N continuing on the other side of the River Mai in the Porol Range to Kundiawa and the Chimbu Gorge. The region is dominated by the massive triangular peak of Mt. Elimbari (2850m.asl.) from which can be seen the entire Wahgi Valley running NW to Mt.Hagen. The scarp face of the Elimbari limestone is very steep and practically unscaleable but modern roads penetrate through

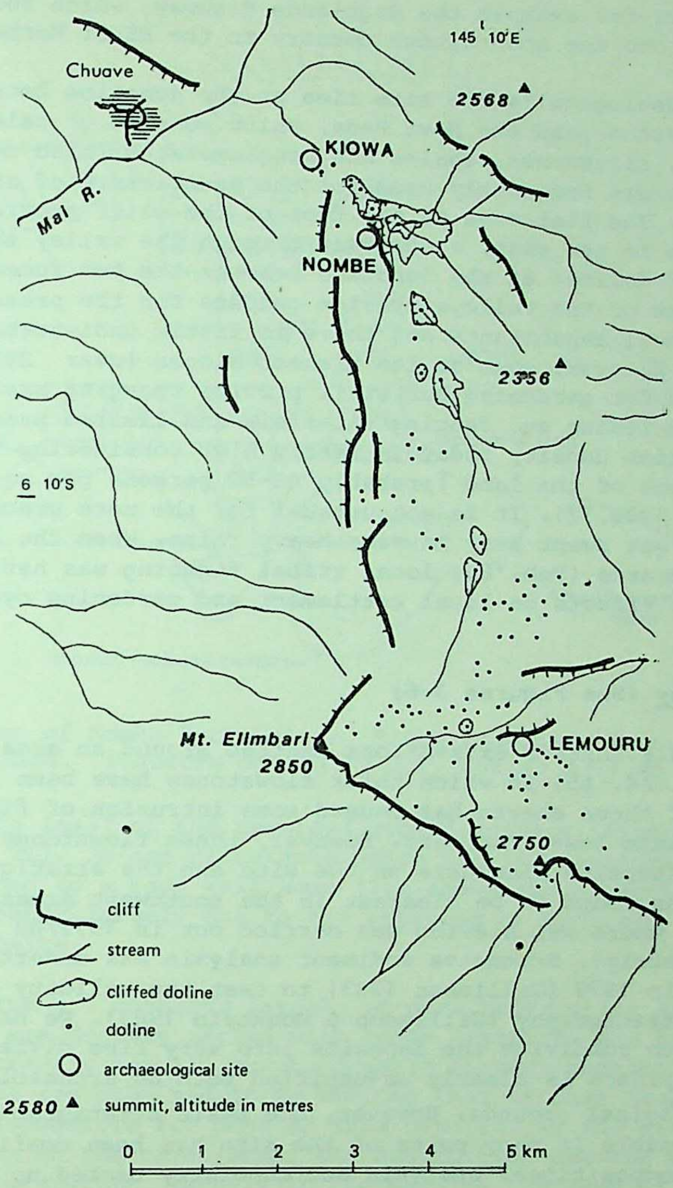


Figure 2. Topographic Features of the Mt. Elimbari Region.

the gaps, as for example the Highlands Highway, which follows the River Mai into the mountainous country to the NE of Nombe.

Geologically the site lies at the junction between the Chimbu limestone and the Movi Beds, which consist of calcareous sandstones, siltstones, shales and conglomerates (also containing chert which was frequently used for the manufacture of stone artifacts). The flat area at the foot of the cliff provides now, as it has done in the past, a routeway through the valley that contains a series of dolines at the junction between the two formations. The steep slopes of the valleys provide gardens for the present Siane speaking local inhabitants and there is little undisturbed bush remaining. However, some of the highest slopes (over 2000m.asl.) are not cleared for gardening but still provide foraging areas for nut pandanus, building and fencing materials and limited hunting zones. The population density today is fairly high considering the steep angle of much of the land (probably 40-50 persons per sq.km.) (Haantjens 1970,37). It is not unusual for the more precarious gardens to get swept away in very heavy rains. When the author was last in the area (Feb.'80) local tribal fighting was having very deleterious effects on local settlement and gardening cycles.

Stratigraphy (See Figures 3-6)

J.P.White's excavations centred around an area (Figure 3: squares TT, A4, A5) in which thick flowstones have been laid down. Cracking of these sheets has caused some intrusion of fine soils and artifacts into lower deposits. However, these flowstones are not as thick or extensive elsewhere on the site and the stratigraphic sequence was found to be clearest in the southwest areas of the excavation where wet sieving was carried out in 1979/80 (Figure 3: Wetsieved strip). Extensive sediment analysis was undertaken by David Gillieson in 1979 (Gillieson 1983) to test the validity of the recorded stratigraphy (Gillieson & Mountain 1983). We have not attempted to subdivide the deposits into very fine divisions since such an approach is clearly unjustified both on archaeological and sedimentological grounds. However, the basic stratigraphy that is clearly visible in many parts of the site has been confirmed by sediment compositional analysis and chemistry backed up by scanning electron microscopy and thin section analysis. A brief description of the 4 basic strata follows:-

Stratum A - top deposits of fine ashey soils varying in texture and colour (10YR5/3, 7.5YR5/2 and 2/2, 5YR1/7). These contain much fireash and are present everywhere on the site although they are now very thin over the top flowstone in squares A4 and A5. Towards the front of the shelter, near the dripline, this stratum is less dusty and more loamy, with much greater depth of deposit (Figure 5: square Z7). In these eastern areas both J.P.White and the author found large numbers of artifacts and bone. The constant human and animal activity in the shelter in recent years has caused up to 40cm

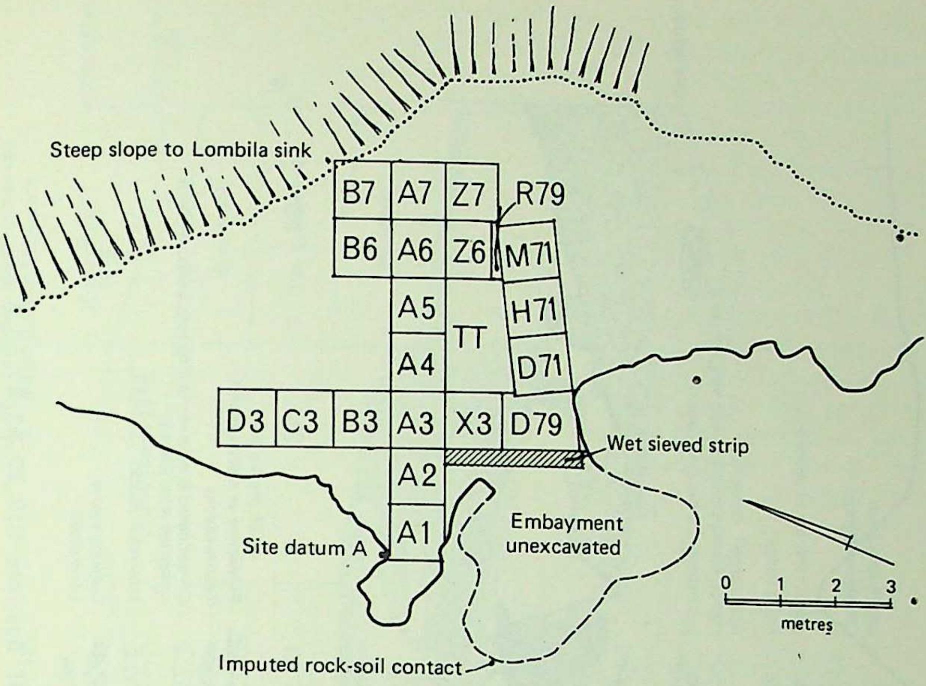


Figure 3. Plan of Nombe Rockshelter, Simbu Province, Papua New Guinea. (Squares opened by J.P. White: A3-7,B6-7,Z6-7)

variation in the level of the recorded ground surface (Figure 5: squares X3 and TT). In one place subsidence has left cultural deposits attached to a rock wall some 15cm above the present top of stratum A, probably largely due to the settling of replaced excavation deposits.

Stratum B - consists largely of dark brown silty soils (5YR3/2) which are densely packed with human artifacts and bone, most of which is extremely heavily burnt. Organic carbon, phosphorus and potassium values are high and it is obvious that intense human activity was responsible for much of this deposit. In the areas towards the back of the cave (west) the distinction between stratum A and B is clearly visible, largely in the massive increase in the density of artifacts (Figure 6 and square X3 in Figures 4 and 5), but this becomes more difficult to see in the more easterly parts of the site.

Stratum C - contains mixed deposits which underlie the thick bone-rich stratum B. It includes the flowstone sheets (Figure 4: squares X3, A3, B3, Figure 5: X3) and, more widespread, evidence of tephra pellets or massive blocks of tephra and fireash (Figure 4: squares A3, B3, D79) set in brown or redbrown soils. In places (ie.square X3) there are blocks of cemented deposits containing tephra, cultural material and sometimes charcoal. The tephras vary in colour from greenish grey (5Y4/2) through bright yellowish brown

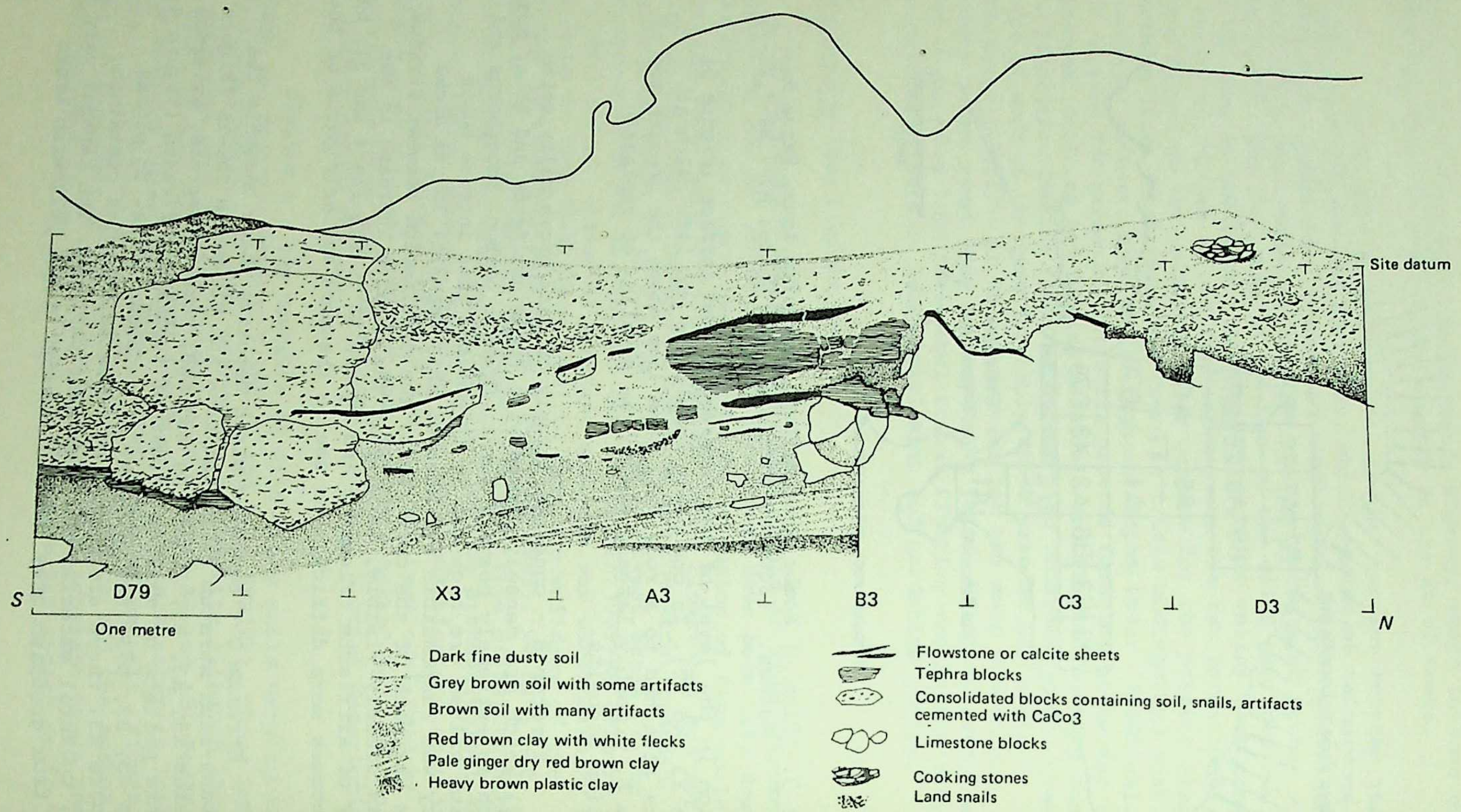
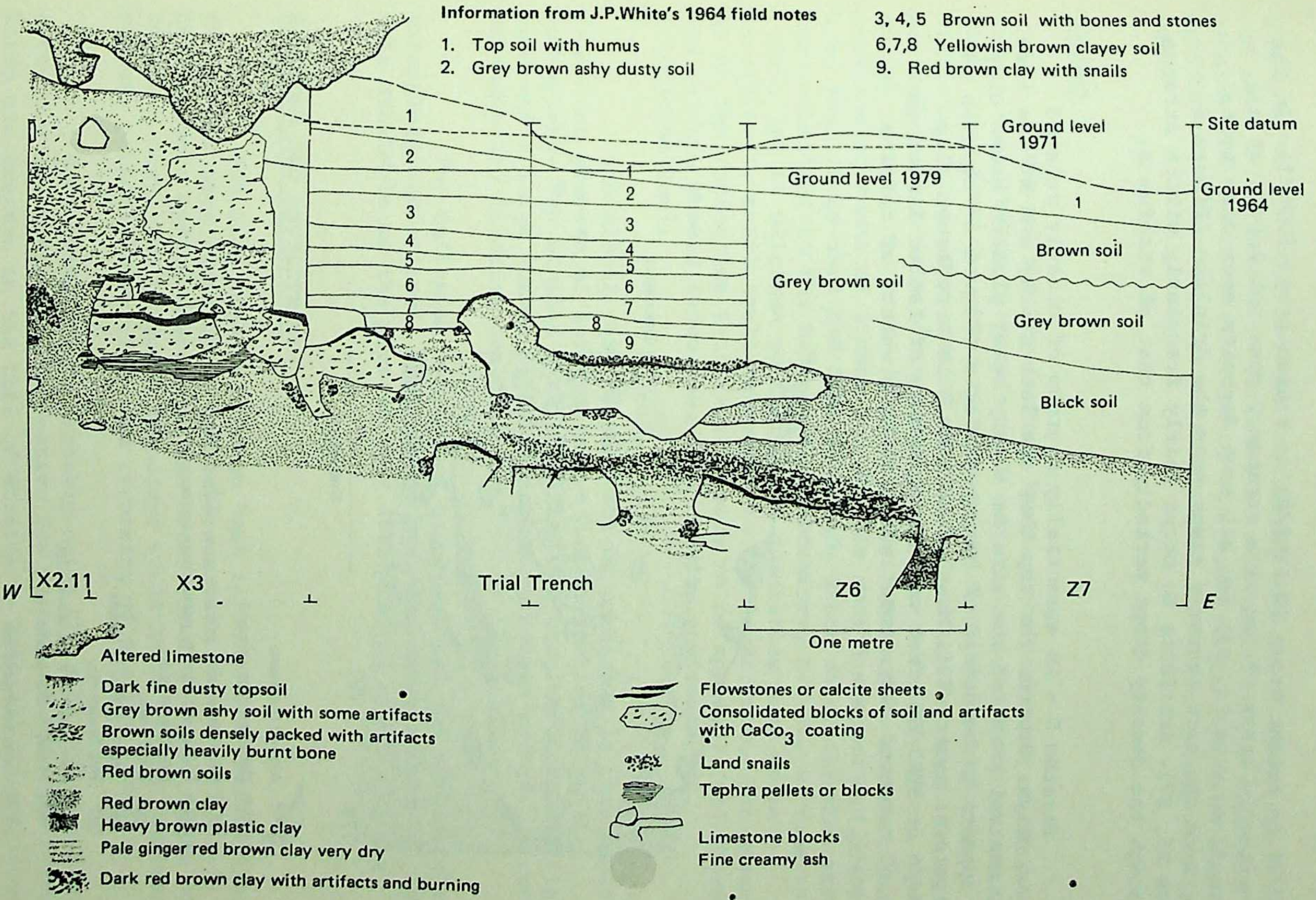

Site datum
S
D79
X3
A3
B3
C3
D3
N
One metre
Dark fine dusty soil
Grey brown soil with some artifacts
Brown soil with many artifacts
Red brown clay with white flecks
Pale ginger dry red brown clay
Heavy brown plastic clay
Flowstone or calcite sheets
Tephra blocks
Consolidated blocks containing soil, snails, artifacts cemented with CaCo3
Limestone blocks
Cooking stones
Land snails

Figure 4. South-North Section Across the East Face of Squares D79,X3,A3,B3,C3 & D3.



Information from J.P.White's 1964 field notes
1. Top soil with humus
2. Grey brown ashy dusty soil
3, 4, 5 Brown soil with bones and stones
6,7,8 Yellowish brown clayey soil
9. Red brown clay with snails
Ground level 1971
Site datum
Ground level 1979
Ground level 1964
Brown soil
Grey brown soil
Grey brown soil
Black soil
1
2
3
4
5
6
7
8
9
W
X2.11
X3
Trial Trench
Z6
Z7
E
One metre
Altered limestone
Dark fine dusty topsoil
Grey brown ashy soil with some artifacts
Brown soils densely packed with artifacts especially heavily burnt bone
Red brown soils
Red brown clay
Heavy brown plastic clay
Pale ginger red brown clay very dry
Dark red brown clay with artifacts and burning
Flowstones or calcite sheets
Consolidated blocks of soil and artifacts with CaCo3 coating
Land snails
Tephra pellets or blocks
Limestone blocks
Fine creamy ash

Figure 5. West-East Section Across the South Face of Squares X2.11, X3, Trial Trench, Z6 and Z7.

(10YR7/6) to bright brown (2.5YR5/8) or bluish grey (5BG5/1). In the more northerly areas of the site stratum C does not appear at all (Figure 4: squares C3, D3) and all such deposits seem also to be absent from the more easterly areas near the dripline (Figure 5: squares Z6, Z7). Artifacts do occur fairly frequently within stratum C although the density drops markedly from that of stratum B.

Stratum D - is essentially a group of clearly related redbrown clays. Towards the top they are less sticky and at the base in the central areas of the site is a very heavy plastic brown clay, which appears to be devoid of human artifacts (Figure 4: squares A3, B3. Figure 6: square X2). Most of stratum D is a redbrown clay (7.5YR4/6 or 5YR3/6) often containing blocks of fallen limestone, blocks of cemented clay, sometimes with thin sheets of calcite

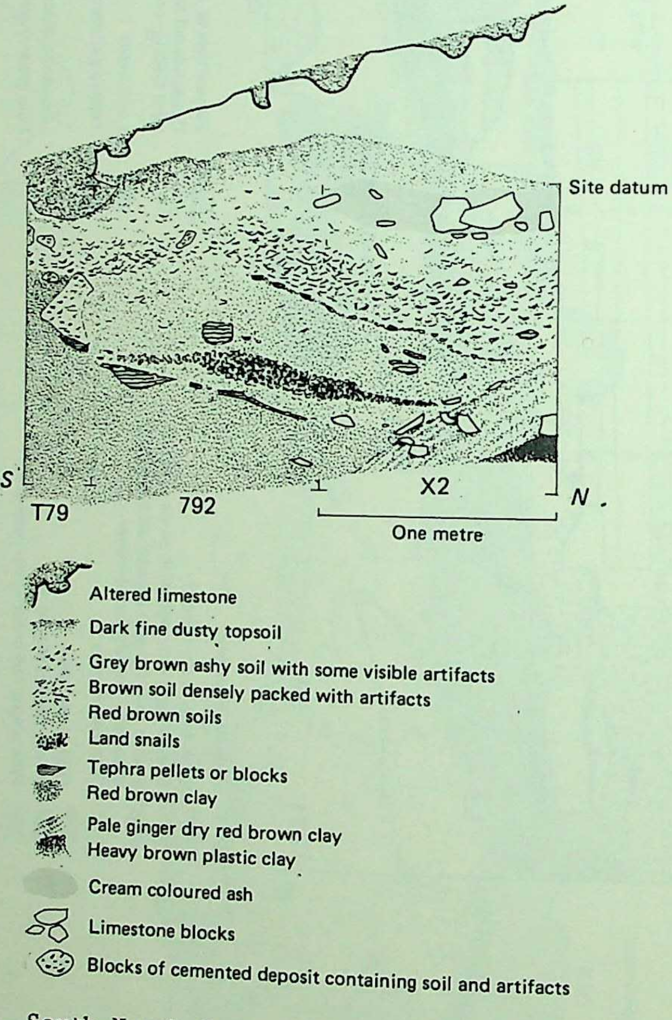


Figure 6. South-North Section Across the West Face of the Wetsieved Strip.

adhering to the top, patches containing soft white limestone flecks and many large lenses of landsnails. Sediment analysis indicates very clearly the close correlation of all these clays. The distribution of artifacts in stratum D is very variable, as is the quantity of animal bone.

Dating

One of the key factors in the interpretation of these deposits and their archaeological components is chronology. Dating at Nombe has, from the onset of archaeological work in 1964, been difficult due to the paucity of charcoal in the deposits. It has been noticed that the ash of the fires that were lit daily at the site during excavations produced practically no charcoal and that the constant movement of humans and animals soon dispersed and powdered even the little that had been produced. Other materials that have been submitted to the Radiocarbon Laboratory, A.N.U., include bone (often low in nitrogen so that large quantities have to be sacrificed), snail shell (abundant in the lower strata but uncertain as to the correction factors that have to be applied), and flowstone and calcite sheets (also requiring careful environmental interpretation).

Individual results will not be published in this paper since the process of interpretation and correction is still incomplete. Two samples were submitted for uranium-thorium dating also and a large number of bone samples have been tested for carbon, nitrogen and fluorine content.

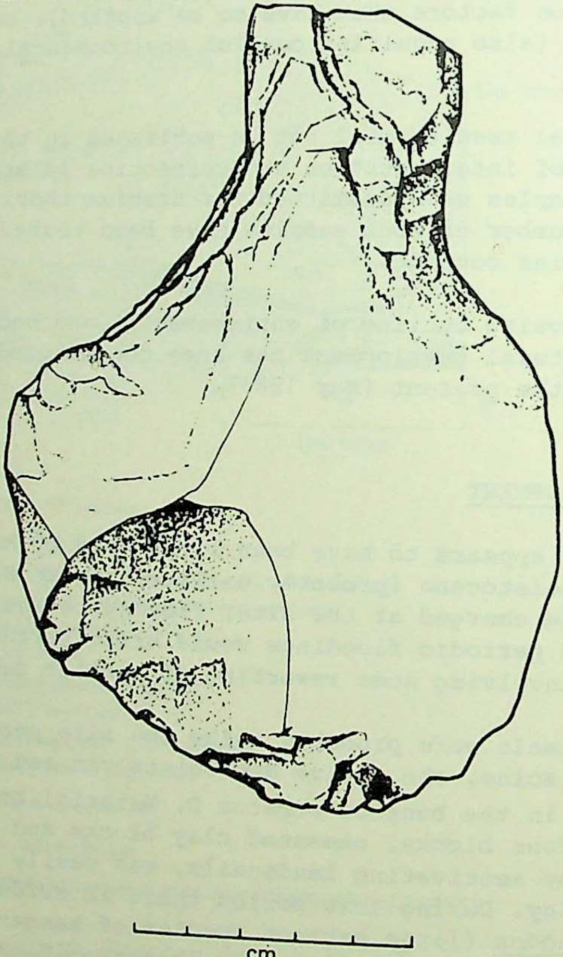
The following outline of environmental and sedimentological chronology and cultural development has been constructed with the data available to the present (May 1983).

SITE USE AND DEVELOPMENT

The site appears to have been first used by human beings during the Late Pleistocene (probably earlier than 26,000 b.p.). At that stage a spring emerged at the site, flowing between banks of redbrown clay, and periodic floodings would bring further sediment pulses, probably involving some reworking of earlier deposits.

Many animals were probably using the site periodically; certainly the thylacine, the native New Guinea cat and some predatory birds are present in the bone of stratum D. Material became lodged amongst the limestone blocks, cemented clay blocks and calcite sheets and, along with any aestivating landsnails, was easily covered by the next deposit of clay. During this period there is evidence of two new species of Protemnodon (large extinct species of kangaroo) and one new large species of the smaller tree-kangaroo Dendrolagus (Flannery, Mountain & Aplin, in press). There are also bones that must belong to a fairly small member of the diprotodontid family, but unfortunately no clearly diagnostic pieces have been recovered. The thylacine specimens vary in size and both larger and smaller specimens are present in this stratum. Dawson (1982) came to the conclusion that there was not enough evidence to justify more than one species of thylacine (Thylacinus cynocephalus) in the samples she had studied from eastern Australia and Papua New Guinea (this included one specimen from Nombe). The variation in the size range may be due to sexual dimorphism or other factors.

Human hunters were leaving occasional stone artifacts, including one complete waisted or stemmed axe/blade (Figure 7). These groups of artifacts are under study by L.Groube, following his finding on the terraces of the Huon Penisula, Morobe Province, Papua New Guinea of a number of large specimens dated to the Pleistocene (unpublished paper given at ANZAAS 1981 in Brisbane and pers.comm). Stratum D also contained an edge-ground axe and many large, heavy, chunky tools, often with a flat, unretouched base and steep flaking on one or more facets of the remainder of the tool. These have considerable similarities with the early core and scraper tradition of Australia.



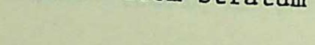


Figure 7. Waisted Axe/Blade from Stratum D, Square M71.

One important question, when trying to interpret the material found in stratum D, is how is it possible to differentiate between bone left by animal predators and bone left by human hunters or scavengers? At present no gross evidence can be seen to answer these questions. The bone does not show easily recognisable marks of butchering or animal teeth marks but it is hoped to try some study with a scanning electron microscope following the methods of Shipman (1981). There are other indicators of human activity in the clays; some areas contain heavily burnt bone, charcoal fragments, lumps of ochre and stone artifacts (Figure 5:square Z6), whereas other regions of identical matrix, such as much of the basal clays in the Wetsieved Strip, contain very little that would indicate a human presence.

The next definite chronological event on the site involves the laying down of the flowstones above the redbrown clays. The earliest of these substantial flowstones appears to have been laid down about 14,500 b.p.and the last one dates to about 10,000 b.p. The fact that the redbrown clays cease to accumulate is probably largely due to a change in the water flow on the site. The gradual process of solutional enlargment must have enabled the stream water, through time, to seep into lower drainage channels in the karst system leaving Nombe dry for substantial periods although probably liable to flood in heavy or very continuous rain. As the regular stream activity slowed down, pools of standing water began to accumulate on the site, often blocked by the impervious clay which was no longer being moved by constant flows of water. We have evidence for gour pool formation in the squares B3 and C3 (Figure 4). As well as flowstone formation, another thick deposit was forming in those standing pools of water; sandwiched between flowstones there is a deposit which is up to 15cms thick. It is gritty in texture and in places very vesicular. In other places it is very clearly laminated We think that this deposit contains tephra probably mixed with fireash blown in from the occupation areas round the standing pools of water. From the dates of the enclosing flowstone it seems likely to be Ep Ash, found in the Western Highlands at the open site of Kuk and surrounding areas (pers.comm J.Golson and R.Blong), and is at present under examination by R.Blong (Macquarie University).

Although there is little cultural material from the flowstones or the tephra blocks in squares A4 and 5, stratum C in other areas, such as X3 and the Wetsieved Strip, contains considerable amounts of artifacts and bone (Table 1). Some specimens of extinct animals occur although not all the species that are found in stratum D recur in stratum C. Certainly the thylacine, one of the two new Protemnodon species and the extinct Dendrolagus are still present. The faunal material is not all analysed at present but it appears that there are more species present in Stratum C over the entire site than in any of the other three strata. There is also a great quantity of landsnails present, as there is in Stratum D. These are presently under study by J.Stanisic (Queensland Museum).

		Densities:expressed in grammes per litre					
Stratum & no.of units	Volume in litres	Bone	Artifactual Stone	Ochre	Snail Shell	Egg Shell	% of total bone burnt
A: 18	119	6.2	1.20	0.08	0.1	0.02	67
B: 25	146	44.0	19.10	1.70	1.3	0.40	91
C: 32	157	11.3	0.50	0.06	7.8	0.02	39
D: 62	320	4.5	0.04	0.03	7.2	Trace	9

Table 1: Archaeological components of all units in the Wetsieved strip

However, apart from the change in waterflow, there may well have been other factors which could partly account for the phenomena present in stratum C. David Gillieson has suggested that changes to the vegetation on the slopes above Nombe could lead to an increase in the amount of soil CO_2 available in the ground water percolating through the site (Gillieson 1983). Variations in soil CO_2 are known to be an important factor in cave drip hardness. Vegetation changes are likely at the end of the Late Pleistocene when it has been suggested by Hope that the upper tree limit might be about 2000 m.asl. (Hope and Hope 1976). Possibly with increased human activity in the area, the slope above the shelter may have been fired, either deliberately during hunting operations, or accidentally, causing immediate and purely local vegetation changes that could be responsible for altering the levels of soil CO_2. Increased human activity is clear from the rise in quantity per litre of artifactual stone, ochre, eggshell and animal bone. The proportion of the bone that is burnt also increases in stratum C from that found in the lower redbrown clay levels (Table 1).

After about 10,000 b.p. the thick flowstone sheets do not recur and neither do the extremely thick tephra blocks. However, there are small pieces and pellets of tephra in the Holocene deposits of Stratum B. Precise dates for this stratum only occur at present in one area at the back (west) of the site. Here, three bone dates indicate a rapid buildup of up to 50 cms within no more than 2000 years, beginning about 6500 b.p. Stratum B contains the highest quantities of artifacts per litre for the site; these include very heavily burnt bone, considerable quantities of various coloured ochre lumps, eggshell (both cassowary and megapode), polished stone axes and a wide variety of small flake tools. Also there are occasional fragments of marine shells, both small examples such as cowries that are sewn on to personal decorative bands and the larger shells such as pearl shells used in exchanges.

The analysis of the fauna shows heavy exploitation of the local faunal suite at this time. In about 150 litres of Stratum B deposit, which was wetsieved, there was approximately 6.5 kgs of bone. The range of species is not quite so wide as in stratum C and the hunters certainly concentrated on the medium to small species, especially brushtail and ringtail possums, medium and small macropods, fruit bats, large rats and bandicoots. Larger species such as the cassowary, the tree kangaroo and the zaglossus were still present but have subsequently disappeared from the locality. Increased clearance for new gardens and villages, causing consequent reduction in suitable environmental niches, may have played an even more important role in this decline than the pressures of increased hunting.

The end of this period of maximum human activity at Nombe was probably heralded by the growth of villages in the vicinity. Nombe would become too close to the garden activity to provide hunters with a refuge and they would have had to go to the higher zones above 2000m. to get good return for a night's hunting. The site would gradually become a resting place for people working in nearby gardens or walking from one village to another. Certainly, animal bone, artifactual stone and shell continued to accumulate in moderate amounts. In recent years at least one human burial took place in the site but the quantity of human bone is very low. In the top levels fragments of vegetable matter (pandanus husk or carbonised sweet potato) occur.

Accumulation of the stratum A deposits is greater towards the front (east) of the site, as would be expected. Very recent deposits overlie the eroded eastern edge of underlying clays (Figure 5) causing apparent stratigraphic disconformity. J.P.White found five joining fragments of one polished axe from different depths below the modern ground surface; 10cms in square A3, 10cms in square A4, 10 cms in square B6 and 62 and 69cms in square A7. These and other stratigraphic variations caused by factors such as cementation by $CaCO_3$ or dispersal of fine ashes by the kinetic force of a constant water drip, all reinforce the belief that depth below ground surface is a grossly misleading method of recording in many rock shelter or cave sites. A thorough understanding of the sedimentary processes and the chronology and composition of deposits is required. Also it was found necessary at Nombe to be fully aware of the limitations of stratigraphic interpretation. It was not possible to subdivide the deposits into small units representative of finer divisions of time merely by calling the upper part of some deposit "Later" and the bottom part "Earlier". The factors which cause variation in the speed of deposit accumulation or erosion are many and extremely various. On occasions archaeologists seem to be so keen on providing a close chronological framework for cultural changes that they can naively assume there is a general law of average deposit buildup on sites and interpret the cultural changes accordingly. Wetsieving of deposits in 1979 at Nombe has provided a most detailed suite of even the extremely small fauna (including extremely important land snails), but it has not provided the information to subdivide deposits that were clearly built up quickly in a period of much human movement and activity. Nevertheless, the site is providing one of the first insights into the activities and impact of the first inhabitants in the Highlands of Papua New Guinea and the interaction of human beings, animals and natural physical forces over 30,000 years of time.

ACKNOWLEDGEMENTS

Although the views expressed in this paper are the responsibility of the author, and are largely based on her own fieldwork and analysis, she has also used results from data collected and analysed by David Gillieson during joint fieldwork on Mt.Elimbari in 1979. Discussions between us on many of the topics covered have contributed to the work.

I would like to thank Winifred Mumford for her superb drawings and am most grateful for assistance in the project from the local Siane people, and the independent research done by my colleague David Gillieson, as well as the contributions of Russell Blong, Tim Flannery, Diane Spencer and John Stanisic. Institutions that have contributed either financial or practical assistance include the University of Papua New Guinea, the Australian National University (Department of Prehistory and RadioCarbon Laboratory, Research School of Pacific Studies), the University of Queensland (Department of Geography) and the National Museum of Papua New Guinea. To all contributing to the research I am most grateful.

REFERENCES

Dawson,L. 1982 'Taxonomic status of fossil thylacines (Thylacinus, Thylacinidae, Marsupialia) from late Quaternary deposits in eastern Australia', In Archer,M.(Ed.) Carnivorous Marsupials. Roy.Zoo.Soc.N.S.W.,527-36.

Flannery,T.,Mountain,M-J.,Aplin,K. In press 'Quaternary kangaroos (Macropodidae: Marsupialia) from Nombe rockshelter, Papua New Guinea', Australian Mammalogy.

Gillieson,D.S. 1983 Geomorphology of limestone caves in the Highlands of Papua New Guinea. Unpublished Ph.D. thesis, University of Queensland, Department of Geography.

Gillieson,D.S. and Mountain,M-J. 1983 Environmental history of Nombe rockshelter, Papua New Guinea Highlands', Archaeology in Oceania 18:1,53-62

Haantjens,H.A.(Ed.) 1970 Lands of the Goroka-Mount Hagen area, Territory of Papua and New Guinea. CSIRO Land Res.Ser.27

Hope,G.S. and Hope,J. 1976 Palaeoenvironments for Man in New Guinea, 29-54. In Kirk, R.L. and Thorne, A.L. (Eds) The origin of the Australians. Aust. Inst. Aboriginal Studies, Canberra.

Shipman,P. 1981 Application of scanning electron microscopy to taphonomic problems, N.Y.Acad.Sci.Ann.376-386

Watson,V.D. and Cole,D.J. 1978 The Prehistory of the Eastern Highlands of New Guinea. ANU Press.

White,J.P. 1967 Taim bilong bipo. Ph.D. thesis ,Department of Prehistory, Research School of Pacific Studies, A.N.U.

White,J.P. 1972 Ol Tumbuna. Terra Australis 2, Department of Prehistory, Research School of Pacific Studies, Australian National University.

FURTHER NOTES ON WOODLARK MEGALITHS AND TRENCHES

Frederick H. Damon
University of Virginia

Based on two years of social anthropological research I recently described and interpreted some megalithic ruins, and trenches, apparently associated with the ruins, on Woodlark Island in Milne Bay Province, Papua New Guinea (Damon 1979). Much of that paper tried to demonstrate relationships between the ruins and trenches and present Woodlark culture. In a recent return to Woodlark I re-examined most of the sites and in this paper I indicate something of what I have newly learned. The clear implication of this information is that once there was some kind of complex public works system on the island, a system that needs extensive investigation by someone whose archaeological competence extends beyond my own.

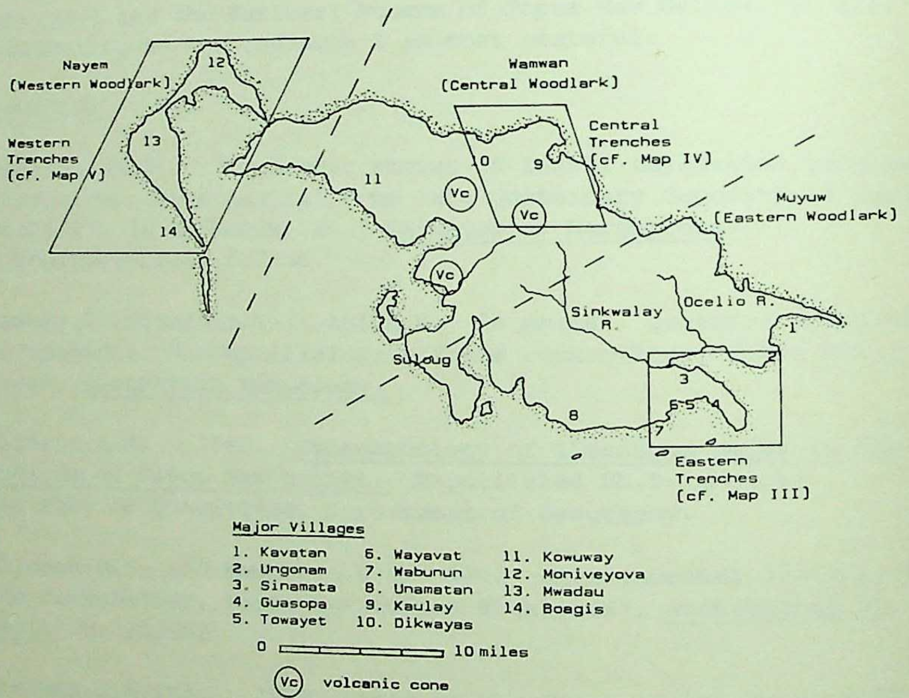
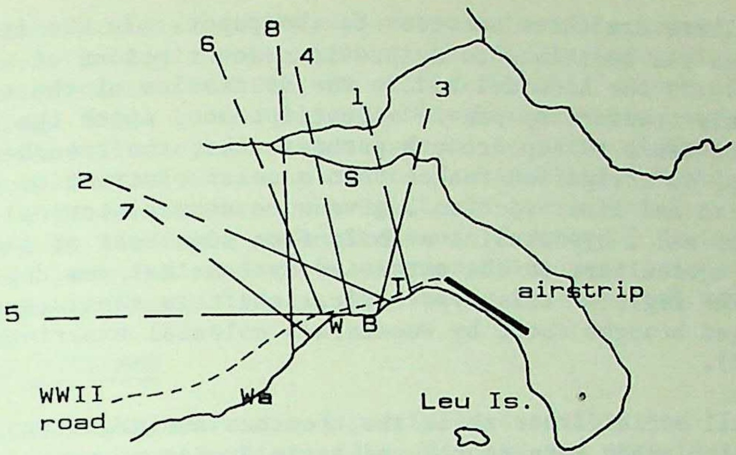


Figure 1. Muyuw (Woodlark Island).



Villages

T — Towayet
S — Sinamat
B — Bomasiu
W — Wayavat
Wa — Wabunun

Trench bearings	
1	349°
2	298°
3	14°
4	348°
5	269°
6	344°
7	309°
8	0° (est.)

All compass readings account for 6° magnetic declination.

Figure 2. Eastern Trenches.

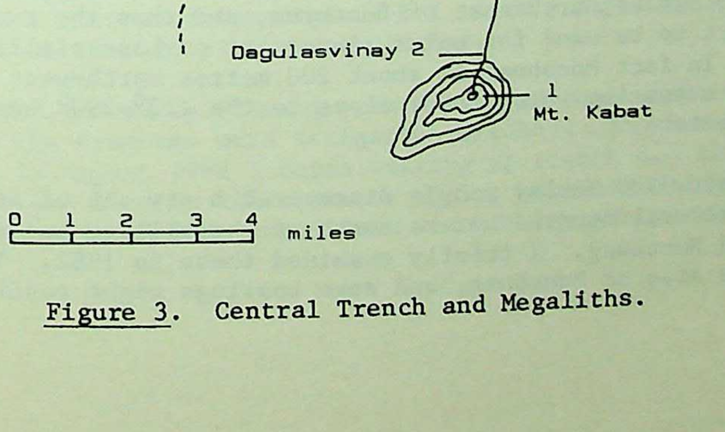


Figure 3. Central Trench and Megaliths.

There are three sections to the paper. In the first I make corrections and additions to my previous descriptions of the megaliths. In the second I add to the discussion of the trenches. Some of this counters my previous descriptions, since the new information tends to support a hypothesis that the trenches are remnants of an irrigation rather than a solar observation system. In the third and final section I give some ethnohistorical information and I hypothesize a shift from some sort of intensive system of agriculture to the extensive system that now dominates the island. The logic of this hypothetical shift is consistent with some changes brought about by Woodlark's colonial experience (see Damon 1983).

All social facts about the trenches and megaliths reported in my earlier paper were reproduced again during my most recent trip, often with new informants. I do not repeat these here. Maps II, III and IV of my 1979 article are here reproduced unchanged as Figs 1-3 (see Acknowledgements).

NEW OBSERVATIONS ON MEGALITHS MADE IN 1982 (Figs 1-3)

According to compass readings I made of each of the two main megaliths, Munobwag and Bunmuyuw (Damon 1979: Figs 1 and 2), two sides of each of these structures come close to a line with bearings of 113°-293° (TN). This bearing connects a December solstice sunrise with a June solstice sunset. I suggested in 1979 that this may be significant because most important Woodlark spatial models - villages, village and garden dwellings, and garden arrangements - are constructed with reference to the sun. I suggested that there might be, therefore, interesting relationships between the qualitative layout of the megaliths and qualitative aspects of Woodlark culture. I then went on to point out possible correspondences between quantitative aspects of the gardens, and the megaliths (1979:223-224). However, these only occurred to me after I left the island in 1975 so I was not able to ask any informants about them until 1982, when informants agreed to the inferences. However, given the quick nature of their responses I do not take these as major support for the hypothesis.

Based on the paths by which I was led to each of the megaliths in 1974 and 1975 I estimated then that Munobwag was about five hundred metres north-east of Bunmuyuw, and thus the two were too far apart to be used for solar, lunar, or perhaps stellar sightings. In fact Munobwag is about 200 metres north-west of Bunmuyuw on a bearing which comes close to the 113°-293° bearing in each structure.

About 1980 Kaulay people discovered a new set of stone structures several hundred meters north of the village and east of Bunmuyuw and Munobwag. I briefly examined these in 1982. They may be about the size of Munobwag, and some bearings might replicate the

113/293° figures evident in the other two main sets. However, the structures were in too poor a state to be quickly surveyed by me. I also examined another set of structures recently uncovered near Kowuway village (Fig. 1, no. 11). Although these were constructed of the same kind of compressed coral found in parts of Bunmuyuw, they were much smaller than any of the Kaulay sites. Myths Kowuway elders tell about these sites may relate to pre-colonial circumstances of Kowuway's economic base. Reports of Kaulay-like structures on peaks of several Suloug mountains were found not to be true, although several pieces of erected igneous rock were seen.

THE WOODLARK TRENCHES

In my earlier article I partially described ten trenches, eight in south-eastern Woodlark (Fig. 2), and one each in central (Fig. 3) and western Woodlark. During my return to the island in 1982 I rechecked all of the calendrical hypotheses presented in my 1979 article, but much of the time I devoted to these trenches concerned examining them to see if they might have once been irrigation ditches. Unfortunately I could not return to Western Woodlark.

I tried to walk the complete length of three of the south-eastern trenches. Based on my earlier report (1979:202) these are trench 1, another newly-discovered one near trench 4, and trench 8. The latter runs on a bearing between about 280° and 330° for a kilometre or more, and commences about 200 metres inland, where it is very distinct. In some places it is five metres wide; its sides are marked by many rocks and the mounds on either side are upwards of a metre high. Unlike all the other south-eastern trenches it is in garden land that has not been used in many years.

Trench 1 seems to be the longest of the three I examined. It may be found about 100 metres inland at Towayet village, and it then runs for two or three kilometres to the southern base of a hill called Sinamat. At this northern end of the trench there is a concavity called Obwanig, about 40 metres in diameter and about one metre deep. In its centre is another shallow concavity about ten metres in diameter. My informant found my idea that Obwanig might have been a reservoir for water, and the trench an irrigation ditch, an interesting idea. He, like most Woodlark people, thinks the trenches are extremely important. But exactly why they are important he, as others, find perplexing.

The concavity Obwanig seemed to lend some support to the idea that the trenches were irrigation ditches. So with another informant in August 1982 I began walking up trench 8. Although it came to an end after a kilometre or so its northern end was also a kind of concavity which ranged from five to ten metres wide and about 100 metres long. It is bounded by what appears to be natural outcroppings of porous coral, more than a metre high in some places.

After careful examination of both trench 8 and its northern end I thought the evidence for an old irrigation system of some kind was fairly strong, but I wanted to examine one more eastern trench. I was shown one, by an elder from Wayavat village, which had about the same dimensions as number 8. It was a kilometre or more in length, often more than a metre wide, and frequently upwards of a metre deep. Its northern end also seemed to be defined by a concavity, but one much smaller than either Obwanig at trench 1 or the concavity of trench 8. However, in its centre there is a hole about a metre in diameter, just less than a metre deep, which may have been a well.[1]

My more recent examination of the south-eastern trenches thus exposed material not seen before, and the same thing happened when I returned to the central area.[2] In both 1974-1975 and 1982, Kaulay informants spoke of one central trench running from Kaulay lagoon in the north to Mt Kabat six or so kilometres to the south. But I found the real situation more complex. This complexity started to come into focus when I found two trenches rising from the south-east and north-east corners of Kaulay lagoon. Each can easily be followed for about 300 metres; they are not connected to each other. Another ditch exists just south-east of the Bunmuyuw megalith and can be easily followed to within fifty metres of it. In one place it is nine metres from crest to crest. About 1500 metres east of Kaulay another may be found and followed for several hundred metres on a north-east by south-west bearing. About 1500 metres west of Kaulay there is yet another which runs on a south-east by north-west bearing. If these last two maintain their southern bearings as I measured them then they would lead to or just south of a place called Kums.

Kums is Kaulay's water source. It is a sinkhole about 100 metres in diameter at the top, 10 at the bottom, and some 10-20 metres deep. Even in the most severe drought it does not dry up. A couple of hundred metres behind Kums three more sinkholes exist, plus several shallower concavities which, conceivably, could be man-made. Two of the three sinkholes are used as water sources when people garden by them, but both obtain water from simple ground seepage so they dry up easily. Kums, on the contrary, is fed by an underground stream. In short, if the Kaulay trenches are remains of an old irrigation system then the problem of where the water came from might be solved by these sinkholes.

In my 1979 article, in addition to describing the large rectangular-shaped ruins of Munobwag and Bunmuyuw, I noted six other named or unnamed rocks which were supposedly associated with the central trench. These are all igneous rocks, apparently from Mt

Kabat. In 1982 I saw an additional ten or so pieces of igneous rock, many of which have dimensions similar to those I earlier described. Most pieces seemed to be roughly shaped into rectangular or triangular blocks upwards of a metre in length. One stands at the apparent southern end of the trench rising from the south-eastern corner of the lagoon. One other may be found in the trench south-east of Bunmuyuw. Another larger piece is in the trench north-west of Munobwag. There are not just two between Kaulay and Kums as I originally reported (Fig. 3, nos 3 and 4), but many. Behind Kums towards the other sinkholes several may be found in recently cut gardens. And at the bottom of Kums another large piece rests beneath several cubic metres of compressed coral rock.

Therefore, I no longer have confidence that I know the limits of the public works system that once existed in the Kaulay area. But it may be suggested that, given the megalithic ruins, the apparent complex system of trenches, and the numerous pieces of igneous rock, what was there was big. Kaulay people themselves do not have a systematic understanding of what lies about them, but I think a careful and patient person could learn more from them than I could in a few weeks in 1974-1975 and a few days in 1982. The Kaulay region needs to be given a thorough archaeological survey.

One final bit of information seems consistent with the hypothesis that these trenches were once irrigation ditches, and this is the name Woodlark people employ for them, usually delikil in eastern, and dakalikil in central and western Woodlark. Kil is the common element in both terms. This could be related to three words, or meanings. The first comes from the word kelkil, which refers to a bird Woodlark people think flies to their island, from the Trobriands, about March every year. Its arrival announces the yam harvest, which may begin about March, but does not become earnest until June or July. The harvesting is done with a stick called kil, and when used as a verb the same word describes the action of harvesting yams. This is the second meaning of the term. The third, now unrelated to the first two, is also a verb, and it means to dip water out of a well. The Woodlark language expresses continuous action by duplicating all or part of the verb, and so to dip water continuously from a well is kilikil, or sometimes kelikil. In this form the term harkens back to the name for the trenches, delikil or dakalikil, and is not inconsistent with an interpretation of the trenches as irrigation ditches. I pointed this out to informants, and some of them recognized the relationship.

DISCUSSION

I am interested in this material for what it can tell us about the past and present social system in which Woodlark culture is embedded. The first issue I address is the possibility of a social hierarchy in Woodlark culture. Because Woodlark symbolism is so radically different from the concentric and hierarchical principles easily observed in Trobriand culture, and because virtually no hierarchy is observable on the island, this is not an issue I took very seriously until just recently. About two years ago I deduced the possibility of hierarchy by comparing the consequences of certain kinds of exchanges. These exchanges occur between a number of different kinds of social units, the details of which need not be adduced here. But they all involve exchanging food, usually vegetable food, for some kind of craft product. Considered just as exchanges their manner seems to involve equivalence only. When one attends to how the exchanged things are used, hierarchy emerges. Domination in Woodlark culture is most often expressed by A being able to feed B, and controlling B because of that. In the food-for-craft-item exchange A gives B food and controls him thereby, and B's return of craft products reproduces the conditions whereby A dominates. This model is derived from present Woodlark culture, and when I applied it to what I had first learned in 1973-1975 the villages of Dikwayas and Kaulay in central Woodlark emerged as top-ranked. When I returned to Woodlark in 1982 I explored the model's implications with various informants. I now turn to the resulting ethnohistory.

Dikwayas and Kaulay villages each sit just south of the only two protected bays on the northern side of the island. Both are, therefore, well suited to be centres in an inter-island communication system. And, given that Kaulay's lagoon is better suited as a harbour for small sailing craft than Dikwayas's Waspimat Bay, it might be understandable that Kaulay rather than Dikwayas became a major centre. Although a few natural features of Dikwayas's immediate environment receive special or ritual-like elaboration, there is so far no evidence of anything like the megaliths, igneous rocks, or trenches around Kaulay. However, both Dikwayas and Kaulay elders told me that each village's present location follows 19th century European communication patterns, not indigenous principles. Until Europeans had the dangerous southern side of the island mapped, most vessels approached the island on the safer northern coast. Although informants thought that both the Dikwayas and Kaulay landings were used by Woodlark people before the arrival of Europeans, the previous incarnations of these two villages were towards the centre, rather than ends, of the six kilometre path that now connects them. Only with the arrival of Europeans did they move to their present areas, although 'Kaulay' first splintered - to avoid working for Europeans - before it was gathered just south of the lagoon.

The best known of these old villages is Kaulay's precursor, called Kuwmwasin. If informants' statements are correct this might have been a kilometre in length, with its western end near a hill, and its eastern end near the western-most trench some 1500 metres west of today's Kaulay. By today's standards this is an extremely large village. Seligmann (1910:675) refers to a village with 80 houses, probably Dikwayas, seen in the early 1890s. I did not believe that figure until I heard of Kuwmwasin in 1982. Informants also find Kuwmwasin's size remarkable. Its name is an indication of this. Mwasin may be translated by "shame"; ku- is a second-person locative and -w is a distance marker meaning something like "a short distance away from both the speaker and hearer". The sense they give to the village's name is "You are ashamed when you arrive there because it is so big". I do not know exactly when this village collapsed, but from informants' statements 1850 is a reasonable guess.

Kuwmwasin was the first social fact I learned that began to fit the model of hierarchy I deduced shortly before returning to the island in 1982. Several other points, however, quickly followed. First, Kuwmwasin was big because central Woodlark people are of high status. Second, the term they employ for this rank is guyaw, a clear cognate to the Trobriand term used to describe persons of chiefly rank. In 1982 people both inside and outside of central Woodlark told me that that area was the location of the island's guyaws, although in the Trobriands guyaw status seems tightly bound up with the category subclan (dala), whereas in Woodlark it seems to be an attribute of people in a place. Third, central Woodlark people are buried sitting upright in a "guyaw position" whereas people in other places are buried flat on the ground. Fourth, for much of this century Dikwayas has dominated the island in the Kula. In other work (1980b, 1982b) I have interpreted this domination as a direct result of the colonial context, but there is now a possibility that some derived from a pre-colonial structure.

Another way some central Woodlark people account for their higher rank is by their potential ability to produce more food than other areas and to make bigger rituals. Woodlark people describe the soil along a "bitter"/"sweet" gradient; "sweet" soil is better for gardening than "bitter" soil. The further west one goes, even to the Trobriands, the "sweeter" the soil. Hence central soil is better than eastern, and western soil is better than central. Although some eastern villages think, correctly, that they produce more than central villages, they also think central people should be better gardeners than they are. And everybody knows that while western soil is better than central soil, there is not very much of it. So given Woodlark evaluations of their soil there is an environmental condition in the central area which could facilitate a high position in a rank system.

Given all the above the following characteristics emerge for central Woodlark: more focussed entrances and exits to cultures to north and west; more and/or better soil than other places; more vegetable food and larger rituals; larger villages; highest rank. While causal links between these characteristics might seem obvious, on the scale of comparative world ethnography there is no necessary correlation between garden productivity and concentrated populations. When, however, the craft item/food exchange is viewed from the point of view of production, and when gardening is fitted into the dynamics of the Kula, these relationships make more sense.

By craft item I refer to such products as stone tools, wooden products (middle and small-sized outriggers, wooden platters, sago troughs and handles for sago hammers and adzes), and, in a specified context, pigs, coconut leaf skirts, sleeping mats and coconuts. The last four items come from Budibud (Laughlin Islands), a set of small islands to Woodlark's south-east; all were and are exchanged for sago or other vegetable food. All craft items require individualized production, or, as in the production of pigs, would seem to gain little if anything from large scale collective work. Some might suggest that gardening, in either intensive or extensive regimes, might be the same. But especially in an extensive regime there are occasions when large inputs of labour are a great advantage. In Woodlark this becomes even truer when gardening is linked to one of its main purposes, supporting the Kula.

I have described the relevant Kula dynamics elsewhere (Damon 1980a,b, 1982b). Briefly, a person Kulas to produce his name. He does this first by exchanging more Kula valuables with people usually outside his village. He initiates and maintains his relationships with these people by being able to assist them in their various Kula and kinship obligations, and this means supplying them with vegetable food, pigs, and other things. In other words, to expand his name, he must expand his Kula, and to do that he must either produce more non-Kula products or obtain them from other people. If he obtains this assistance from other people without facilitating their own Kula he is exploiting them, and they leave him. Hence wise Kula action involves building up larger sets of people who Kula together and who share in the full range of productive work that goes into the Kula. Institutionalised successful Kula must create more concentrated population centres. Dynamics like this are observable in this century (Damon 1980b), and it is likely that something like them operated in the past. I was told that most large Kula relationships went into both Kaulay and Dikwayas before about 1920; since then most have just gone into Dikwayas.

The existence of the Kaulay megaliths and standing igneous rocks is consistent with these dynamics. If these things were only involved in 'ceremonial' or 'ideological' issues they might have represented the ideological side of the domination of their builders over others in the culture. If the megaliths, igneous rocks, and trenches were part of an irrigation system instead then they might have been more directly involved in the conditions which created and sustained that domination, directly at the level of intensive production rather than indirectly at the level of ideology.

Two questions now follow. There were large villages west of Kuwmwasin, according to informants, but so far there is no evidence, visual or oral, of trenches there. Why? Second, if trenches are associated with higher rank in central Woodlark how can they also be associated with lower rank in south-eastern Woodlark?

A possible answer to the first question is that many of the valleys in the area west of Kuwmwasin are swampy, and natural rather than canal irrigation may have been possible. To the second question some Woodlark ethnohistory might supply the answer. Central Woodlark people told me that in the past they concentrated on both yams and taro, as they do today. However, in south-eastern Woodlark the situation was different. There, in the past, taro was the main crop whereas now yams are the most important. The relative dominance of yams in this region can be tentatively dated to have occurred between about 1900 and 1930. As this change is understood today it is tied to the phenomenal rise and success of Wabunun. It might also be related to the collapse of a region called Kweyakwoya. Before indicating the relevant facts for each area let me describe what people think about yam as opposed to taro production.

Woodlark people think yams need less water than taro and are more resistent to drought than taro. They also think that with too much water yams either do not grow well or they tend to rot. But too much water is either irrelevant to taro production or advantageous to it. Although they prefer taro to yams for eating, yams are more prestigeous as exchange items. At least one reason for this is that yams can be stored longer, and they also think yams are more productive than taro, soil conditions remaining constant. One man estimated the difference in a ratio of 5:2.

The elders in south-eastern Woodlark told me that in the past taro was grown more, and was more important than yams. This changed with the rise of Wabunun, who, until about 1978, gardened on land west of trench number 8 in south-eastern Woodlark. The land from there west almost to Unamatan and north to the Sinkwalay river is relatively flat and, for the southern side of the island, relatively high and dry. Correspondingly, although Wabunun has always maintained large taro stocks, its success came from dramatically increasing its yam gardens. It converted this success into an extremely powerful position in the Kula, and helped redefine the structure of the Woodlark mortuary system. In the past the mortuary rituals did not involve distributing large amounts of yams; now they do. To try to match Wabunun's success other villages started concentrating on yams in the same way.

Kweyakowya is the name of a region in south-eastern Woodlark that existed from the top of Sinamat hill west along the southern side of the Sinkwalay river, and also on the land just below Sinamat hill on its south-western side. When I was shown trench 1 and its northern end, the concavity Obwanig, I had several old Kweyakwoya villages pointed out to me. All are now overgrown, and they were south of Obwanig. Although trench number 1 clearly goes into the old Kweyakwoya region, the other two trenches I examined in 1982 only went to its southern boundary. In 1974-75 several elder Kweyakwoya men told me about trenches that went through the region; these I did not see, although I may have seen their southern ends.

In the old Woodlark scheme of things Kweyakwoya's work was carving wooden materials. It was a craft-specialization area, and thus, given the ranking scheme through which I now view Woodlark culture, it was towards the bottom end of the system. It never had particular success in the Kula, but it is now remembered as the location of the island's fiercest warriors, a point consistent with my ranking system. Its inhabitants were not supposed to be very good gardeners; they exchanged their wooden products for vegetable food. But the gardens it did have were supposed to be taro gardens.

If this ethnohistory is correct then at least two points emerge. Trenches, and perhaps irrigation, existed in two different areas, but socially these areas were not identical. Central Woodlark grew both yams and taro, but south-eastern Woodlark not only grew just taro, but it was devoted to other productive activities as well, carving in the Kweyakwoya region and fishing along the southern shoreline. Carving requires great concentration and considerable time, and fishing, at least today, is organised by the island's tidal rhythms. Some of this I have discussed elsewhere (1982a). Hypothetically then the trenches in the central part of the island were part of that area's major activity whereas those of the south-eastern part were used to supplement major activities.

The second point this ethnohistory raises concerns a hypothesis to explain Woodlark's most recent social change. My argument here may be incorrect but to illustrate it I must provide information which might be useful for constructing a better argument.

The only real sign now of central Woodlark's high rank is the burying corpses in a sitting position. However rich that might appear from a symbolic point of view it can not be the basis of a rank system of any significance. Vegetable food, however, could be the basis of such a rank system, and central Woodlark people claim they can produce more than anybody else. But now they do not do that, and they do not significantly support other regions on the island. If they did so in the past it is significant that correlated with the decline is the generalisation of yam production throughout the whole island. All this implies that over the last 100 years the Woodlark social structure has been leveled, a by-no-means untypical response to the spread of commodity production. If a switch from an agricultural regime using intensive agriculture to one using only extensive methods is involved in such a process, what might be the logic to this?

Woodlark people classify their garden land into three main divisions, digadag, oleybikw, and ulakay. These terms describe both the numbers and sizes of trees on the land, and by means of these terms people describe fallow periods. Digadags have the most but smallest trees, and the soil is weakest. Such land is that having been gardened in the last ten to fifteen years. Far western Woodlark aside, this land is rarely used for serious gardening. Oleybikw refers to land which has fewer but larger trees, land not used in the last fifteen to 40 years. During my two research periods most people were gardening on such land. Ulakay refers to land not having been used in the lifetime of the eldest members of a community. Ambitious people try to use some of this land every year. The obvious inference from this is that Woodlark people garden under the assumption that their land is poor and requires a long time to regain its strength. The correlary of this is that each Woodlark village must have massive areas of land to set aside for such long fallow periods. This is not a problem now since the island's population is so small. But in the past?

There is another side to this issue. People now frequently cut down trees twenty and more years old with iron axes because they think they have to do that to garden on fertile soil. Although most enjoy that work they also wonder how their elders did it in the past with stone tools which, as they know, did not cut wood so easily. If, however, their elders had an irrigation system that required less forest clearance then perhaps it could be hypothesized that the present system is largely a product of the availability of iron.

If this inference is reasonable then it follows that irrigation agriculture was used on Woodlark in the 19th century. If that is true then why do people know nothing of it now? I can not answer that question, but I can report that they also know little of the process of producing stone tools, and the Suloug stone tool industry probably only went out of operation about 1870.

CONCLUSIONS

Much of the argument in this paper is deductive. I am aware of the serious limitations in such a method, and I am aware of how much needs to be known before we will really have a good idea about what the megaliths and trenches on Woodlark mean. A move from intensive to extensive agriculture seems "backward". But it ought to help pose new questions for future research, and if recent work in other tropical zones is of any significance, the movement may not be novel (see Mathewson 1977; Sanders 1973, 1977).

There may be a final point. With the arrival of a logging company on Woodlark in 1981 the island has entered a new phase of colonial incorporation. As a condition of that logging the island is being asked to initiate larger-scale capitalist agriculture. As I understand the government's requirements their model is based on temperate zone agriculture. Perhaps Woodlark's past would offer a better model. Woodlark's artefacts make research into its past intellectually exciting. They might also provide a better model for the future.

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Figures 1-3 have been reprinted from Archaeology and Physical Anthropology in Oceania (Damon 1979), with the editor's permission.

FOOTNOTES

1. The water source for this hypothetical irrigation system puzzles me, and all informants willing to consider the issue. They know of no springs between the south-eastern shoreline and the springs at the northern base of Sinamat hill. None of the available geological reports (e.g. McGee 1978) deal with the issue, although it is clear that below ground level much water exists. McGee (personal communication) believes that geologically the island is changing very fast. He thinks that as little as 1000 years ago the island might have had a noticeably different appearance. Might there have been more water near the surface in the past? Now most villages obtain water from the shoreline springs.

2. I received detailed descriptions of two trenches north and west of Unamatan village (Fig. 1, no. 8). Informants indicate much evidence of old villages in this area.

REFERENCES

Damon, F.H. 1979. Woodlark Island megaliths and trenches: towards an interpretation. Archaeology and Physical Anthropology in Oceania. 14:195-226.

---------- 1980a. The Kula and generalised exchange. Man (N.S.). 15:267-293.

―――――――― 1980b. The problem of the Kula on Woodlark Island. Ethnos. 45;3-4:176-201.

―――――――― 1982a. Calendars and calendrical rites on the northern side of the Kula Ring. Oceania. 52:221-239.

―――――――― 1982b. What moves the Kula: opening and closing gifts on Woodlark Island. In The Kula: new perspectives in Massim exchange (eds J.W. Leach and E.R. Leach), pp.309-342. Cambridge University Press.

―――――――― 1983. On the transformation of Muyuw into Woodlark Island: Two minutes in December 1974. The Journal of Pacific History. (Forthcoming)

McGee, W.A. 1978. Contributions to the geology of Woodlark Island. Geological Survey of Papua New Guinea, Report 78-10.

Mathewson, K. 1977. Maya urban genesis reconsidered: trade and intensive agriculture as primary factors. Journal of Historical Geography. 3;3:203-215.

Sanders, W.T. 1973. The cultural ecology of Lowland Maya: a re-evaluation. In The Classic Maya collapse (ed. T. Patrick Culbert), pp.325-365. University of New Mexico Press, Albuquerque.

―――――――― 1977. Environmental heterogeneity and the evolution of Lowland Maya civilization. In The origin of Maya civilization (ed. Richard E.W. Adams), pp.287-297. University of New Mexico Press, Albuquerque.

Seligmann, C.G. 1910. The Melanesians of British New Guinea. Cambridge University Press.

SITE FORMATION PROCESSES AND CULTURAL SEQUENCE AT TARAGUE, GUAM

Hiro Kurashina and
Russell N. Clayshulte
University of Guam

INTRODUCTION

Guam, the largest high island in the Mariana Archipelago in Micronesia, has over 100 archaeological sites as identified by Fred Reinman (1977). Prehistoric settlement sites are found most extensively along the coastal zone and to a lesser extent in interior uplands and river valleys. On the northern coast of Guam, a series of archaeological scatters occurs along the beach berm at an elevation of 7-10 m (20-30 feet) above present sea level. A high density of cultural material is found near the Tarague Channel in association with remains of megalithic stone structures, locally known as latte stones. The latte stones, most of which are fragmentary, attest the presence of permanent settlement at Tarague prior to the European contact in the 16th Century A.D. In his pioneering work in the Marianas, Alexander Spoehr (1957) made use of latte as a cultural marker to distinguish the Latte Phase (9th Century A.D. - 17th Century A.D.) from the earlier, pre-latte Phase (ca. 1,500 B.C. - 9th Century A.D.), to establish the regional cultural history.

At Tarague (N13°36'; E144°54'), an archaeological investigation carried out in the 1960's by Erwin Ray (1981) produced evidence of human occupation extending well into the pre-Latte Phase. A multi-disciplinary research program has been in progress at Tarague by University of Guam scientists and students since 1980, in an attempt to date the cultural deposits, to explain possible causes of culture change from the earliest aboriginal culture (pre-Latte Phase) to that of the megalith builders of the Latte Phase, and to examine site formation processes and the uses of space and resources within the context of island ecology. In this paper, preliminary results of geoarchaeological research carried out in 1980-82 are presented with particular emphases on site formation processes and cultural sequence at the Tarague site in northern Guam.

SITE FORMATION PROCESSES

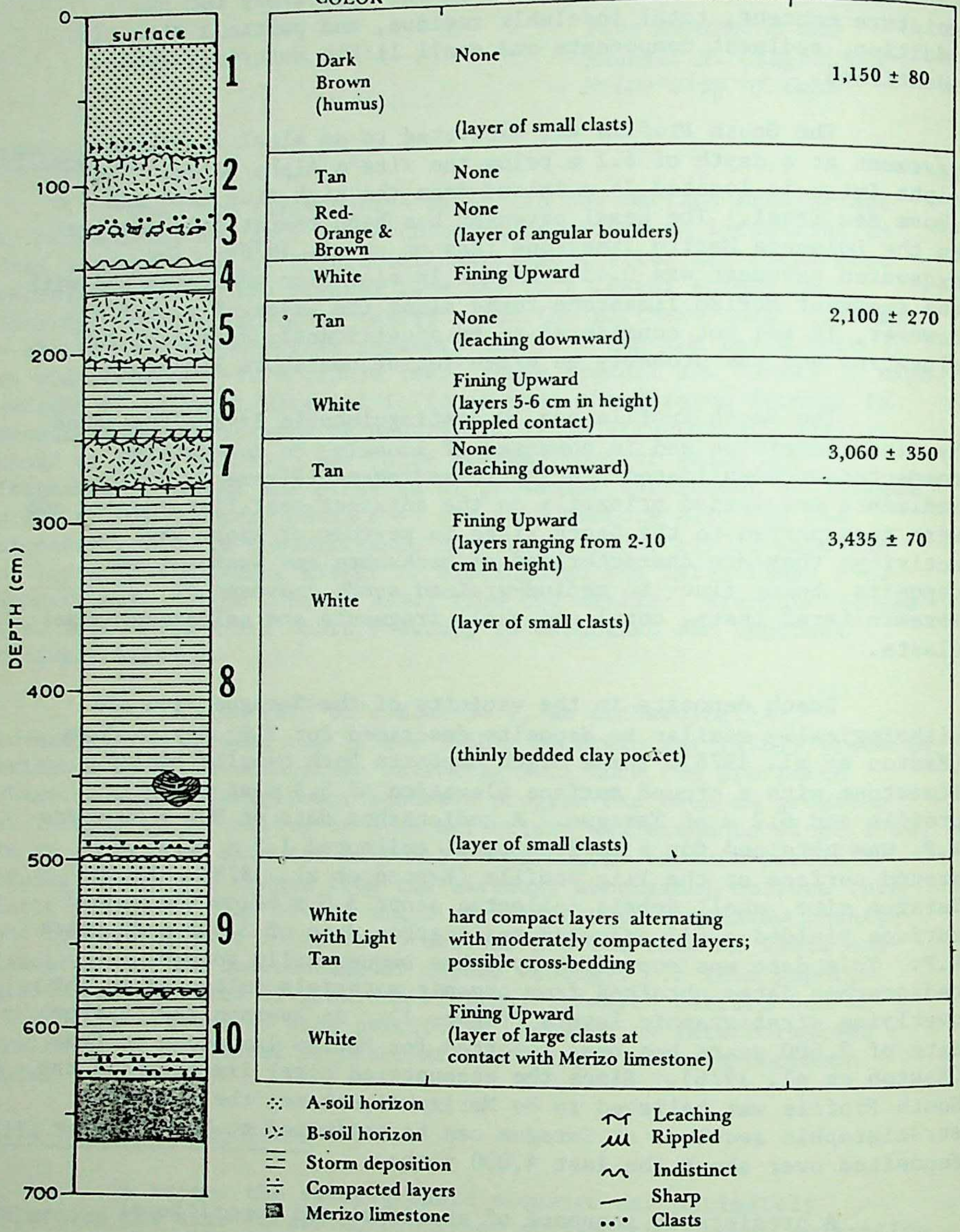
To assess the stratigraphic sequence and ultimately determine the site formation processes at Tarague, a test excavation was carried out in an area measuring 3 m x 1 m at the South Profile. The field methodology involved visual examination of exposed geological layers with particular attention paid to sediment color, texture, grain orientation, apparent sorting, bedding sequences and types, large structural components, large lithic materials and cultural remains (Figure 1). Sediment samples were systematically taken from all layers and analyzed in the laboratory for pH, moisture content, total insoluble residue, and particle size. In addition, sediment components and small lithic materials were identified.

The South Profile was excavated to an algal limestone pavement at a depth of 6.2 m below the site's Alpha Datum. The Alpha Datum is located 74 m inland from the high tide line and 7 m above sea level. The basal pavement has been tentatively assigned to the Holocene Merizo limestone (Easton et al. 1978). The excavated pavement was 0.45 m higher in elevation when compared with the emergent Merizo limestone found along the adjacent reef flat. However, it was not considered to be significantly different in elevation and was probably an extension of nearshore limestone.

The South Profile has 10 distinguishable layers separated by disconformities and is composed of loosely- to moderately-compacted unconsolidated bioclastic sediments (Figure 1). These sediments originated primarily on the adjacent reef flat complex and were transported to the beach ridge in periods of storm wave activity; they are characterized as backshore and washover fan deposits, being fine- to medium-grained sands composed of foraminiferal tests, coral and shell fragments and calcareous algae clasts.

Beach deposits in the vicinity of the Tarague site are lithologically similar to deposits described for Ylig Bay on Guam (Easton et al. 1978). These beach deposits both overlie Merizo limestone with a ground surface elevation of 5.3 m at the Ylig profile and 6.2 m at Tarague. A radiocarbon date of 900 ± 80 years B.P. was obtained for a Porites coral collected 1.5 m below the ground surface at the Ylig profile (Easton et al. 1978). At the Tarague site, shell debris collected about 3.0 m below the ground surface yielded a C13 adjusted radiocarbon date of 3,435 ± 70 years B.P. This date was supported by other sequentially younger radiocarbon dates obtained from organic materials collected in the overlying stratigraphic layers (Figure 1). An average radiocarbon date of 3,600 years has been reported for Merizo limestone on Guam (Easton et al. 1978). Since the encountered algal limestone in the South Profile was believed to be Merizo limestone, the entire stratigraphic sequence at Tarague can be estimated to have been deposited over about the last 4,000 years.

A predictable sequence of erosional and depositional processes occurs in periods of storm activity. Peak storm wave activity causes removal of the upper sediment layers and associated vegetation along the berm. Dependent on the storm wave size and duration, a portion or all of the A soil horizon and sometimes part of the B horizon can be eroded. As the storm wave height decreases,



COLOR	BEDDING	C14 AGE B.P.
Dark Brown (humus)	None (layer of small clasts)	1,150 ± 80
Tan	None	
Red-Orange & Brown	None (layer of angular boulders)	
White	Fining Upward	
Tan	None (leaching downward)	2,100 ± 270
White	Fining Upward (layers 5-6 cm in height) (rippled contact)	
Tan	None (leaching downward)	3,060 ± 350
White	Fining Upward (layers ranging from 2-10 cm in height) (layer of small clasts) (thinly bedded clay pocket) (layer of small clasts)	3,435 ± 70
White with Light Tan	hard compact layers alternating with moderately compacted layers; possible cross-bedding	
White	Fining Upward (layer of large clasts at contact with Merizo limestone)	

Figure 1. Stratigraphic Sequence at Tarague South Profile.

the berm and backshore area is subjected to sediment deposition. These sediments are derived from the reef flat and foreshore environment. The sediments which spill over the berm crest are deposited in horizontally laminated beds which show a fining-upward sequence of sediment grains. This depositional type is seen in Layers 4, 6, 8, and 10 at Tarague. At some period of time after the storm event, the coastal vegetation strand re-establishes along the berm. This vegetation strand in conjunction with natural weathering processes produces new soil layers: a dark brown organic A horizon, and a tan B horizon which is produced by leaching and chemical processes. The tan B horizon loses its structure by a combination of chemical, biological and physical alterations. The C horizon is the original storm deposited sediments, which still retain bedding sequences. As a result of this formational process, the stratigraphical facies alternates between white bedded layers and tan non-structured layers with a typical surface soil development. It can be anticipated that a future intense storm event will cause extensive erosion of surface sediment (A soil horizon) and removal of the coastal vegetation strand and subsequent deposition of new sediment derived from the existing foreshore environment.

CULTURAL SEQUENCE

The sedimentary accumulations at Tarague represent one of the deepest archaeological occurrences in the Marianas. The cultural deposits, measuring more than 3 meters in depth from the present ground surface, have yielded evidence of human habitation from the 2nd millenium B.C. onward to the post-Contact period. In terms of the Mariana prehistoric cultural sequence as defined by Alexander Spoehr (1957), Latte Phase occupation horizons are seen in the upper portion of Layer 1 while traces of pre-Latte Phase occupations are found from the lower portion of Layer 1 down to Layer 8.

A preliminary assessment of the Tarague ceramic remains reveals that main pottery types characteristic of the Marianas, such as the "Marianas Plain Ware", "Marianas Red Ware", "Lime-filled Impressed Trade Ware" and their variants, are all present. The ceramic assemblages exhibit temporal variations in rim form, rim diameter, wall thickness, shape, surface finish, and decorative motifs. Layer 8 is the lowest artifact bearing deposit at Tarague, and this has yielded pottery sherds originating from thin walled (2.5 mm - 12 mm), small vessels. The sherds appear to be well fired and show exterior colors which range from reddish orange to dark grey. One body sherd exhibits a distinct corner point. A shell adze made from the umbo section of Tridacna cf. gigas has been found in Layer 8. The adze is almost completely polished, but the bit is bifacially flaked. Another almost completely polished Tridacna cf. gigas shell adze has been found in Layer 2 at the Tarague South Profile. These adzes are extremely rare finds as Tridacna gigas has not been known to occur in the Holocence in the Marianas (Barry Smith, personal communication). Since these adzes must have been imported from elsewhere, they could indicate possible trade or communication networks with islands where Tridacna gigas is known to have been present in the prehistoric context. Marine shells, primarily limpets, collected in the upper portion of Layer 8 give a C13 adjusted radiocarbon age of 3,435 ± 70 years B.P. (Beta-4897).

Layer 7, a compacted tan sand layer representing an occupation horizon, has produced several pottery sherds which have clearly defined corner points and round bottoms. Pottery sherds are relatively thin and do not exceed 20 mm in wall thickness. A reddish slip is suggested by at least one sherd. A radiocarbon date of 3,060 ± 350 years B.P. (UCR-1475B) has been obtained from a sample of fish bone found at 2.7 m below the site datum.

The Lime-filled Impressed Trade Ware, as originally defined by Spoehr (1957), is represented in Layer 6 by a single rim sherd with criss-cross incisions filled with lime making multiple diamond designs on the lip. The rim sherd is reddish brown in color and appears to have a thin red slip. The temporal distribution of Lime-filled Impressed Trade Ware seems to be restricted to Layer 6. The geographic distribution of Lime-filled Impressed Trade Ware in the Marianas has been reported for the islands of Saipan (Spoehr 1957:120-121), Tinian (Pellett and Spoehr 1961), Rota (Takayama and Intoh 1976:13-14), and Guam (Leidemann 1980). This highly distinctive technique for decoration has also been reported from the central Philippines (Solheim 1968) and a link between the Marianas and the Philippines is suggested around 1,000 B.C. (Bellwood 1979:282; Craib 1983). The Lime-filled Impressed Trade Ware has several shared morphological attributes with the Lapita pottery of Melanesia and Polynesia. The infilling of incised or stamped designs with lime, application of a red slip, and certain vessel forms are characteristics common to these ceramic traditions (Green 1979).

Fish bone in Layer 5 has been radiocarbon dated to 2,100 ± 270 years B.P. (UCR-1474A). Pottery decorations appear on lips in the form of opposed triangular impressions or a series of circular stamps. Traces of possible red slip are present on at least one of the decorated pottery sherds found in this layer.

Layer 3 is a distinctively reddened deposit which has an artificially deposited limestone boulder and clasts zone found toward the top center of the layer. Rich in well-preserved pre-Latté phase cultural material, this layer represents intense human occupation as reflected in the high density of archaeological remains. An almost complete shallow vessel with a rim diameter of 36 cm has been recovered. There appears to be an increase in robusticity of the pottery vessels and some sherds approach 40 mm in wall thickness. Designs which appear on the lip of some sherds are finely executed. Two rows of impressed triangular or rectangular designs are found on several rim sherds. A sign of red slip is evident on one sherd. Stone flakes with utilization signs are also present.

The ceramic assemblage of Layer 2 includes simple rim sherds with impressed designs on the lips. A drilled rim sherd has been found with a hole diameter of 6 mm. Drilled or perforated pottery sherds have been reported from other sites on Guam (Reinman 1977: Figure 21) and elsewhere in Micronesia including Rota (Takayama and Egami 1971; Takayama and Intoh 1976), Yap (Gifford and Gifford 1960) and Palau (Osborne 1966; 1979; Hidikata 1973; Dave Snyder, personal communication). Although drilled perforations have been interpreted as suspension holes (Spoehr 1957:109), the specimen from Tarague does not show sign of wear which might have been caused by friction from the suspending substance.

The top layer, Layer 1, is uniformly dark brown-black in color and is largely humus soil rich in organic residues. The top 70 cm of Layer 1 contains typical Latte phase elaborated rim forms. In addition, triangular shaped shell adzes made from Tridacna maxima, basalt adzes, fish hooks/gorges, and numerous burnt fist-sized limestone fragments are found in this layer. The lower portion of Layer 1 contains material which may be considered the terminal part of the pre-Latte Phase and a transition to the Latte Phase. A 20 gram charcoal sample collected from the 70 cm level has a radiocarbon age of 800 ± 80 years A.D. (UCR-1472). The age is comparable to the radio-carbon date from Blue I on Tinian, 845 ± 145 A.D., which has been commonly regarded as the lower age limit of the Latte Phase (Spoehr 1957:85, 171).

DISCUSSION

The geoarchaeological research carried out at Tarague in northern Guam has revealed that the antiquity of human settlement in the Marianas extends to the 2nd millenium B.C. The stratigraphic layers reach to 6.2 m below the ground level at the South Profile. These layers are separated by disconformities and are composed of loosely- to moderately- compacted unconsolidated biolastic sediments. At the base of excavation in the South Profile is an algal limestone pavement of shallow reef origin, which is tentatively assigned to the Merizo limestone. Since the top of the Merizo limestone on Guam has been dated to a maximum age of about 5,000 years B.P. and an average age of 3,600 years B.P., the entire stratigraphic sequence at the South Profile can be estimated to have been deposited over the last 4,000 years. A series of radiocarbon dates obtained for Layers 1, 5, 7, and 8 at Tarague provides a chronological framework for better understanding Marianas cultural history. Charcoal, bone, and marine shells have been dated to calibrate the age of deposits at Tarague at two radiocarbon laboratories in the United States. The results of the dating are consistent with cultural and geological events as portrayed in the South Profile and make Tarague one of the most securely dated archaeological sites in the Marianas. Furthermore, the two radiocarbon dates in association with the lowest artifact-bearing deposits of the pre-Latte Phase, Layers 8 and 7, establish Guam as one of the earliest islands colonized by people in Micronesia.

In the Marianas, the absolute chronology of early prehistory was developed based on radiocarbon dates from a relatively limited number of archaeological sites on Pagan, Saipan, Tinian, Rota, and Guam. References to the date of 3,479 ± 200 years B.P. obtained from Chalan Piao on Saipan by Spoehr (1954; 1957) have been frequently made by authors as the oldest age of human settlement in the Marianas or in Micronesia (Clark 1977; Craib 1983; Howells 1973; Intoh 1982; Shutler 1978). This date was initially calibrated on an oyster shell (Ostrea cucullata Lamarck) found at Chalan Piao at a depth of 0.45 m and was first published in Science by Libby (1952). According to Spoehr (1957:169), the levels contemporaneous with and below the dated oyster shell yielded Marianas Red Pottery, the earliest known ceramic tradition in the Marianas. However, re-examination of the Chalan Piao sample designated as University of Chicago No. 669 was conducted by L.J. Kulp in January 1953 employing a "new" conversion factor (Cloud et al. 1956:87). The corrected age for the Chalan Piao oyster sample was 1,730 ± 450 years B.P. Assuming that the recalibrated age was valid, it makes the revised date some 1700 years younger than the original date published by Libby. Aside from the 1,485 ± 70 B.C. date obtained for Layer 8 and the 1,000 ± 350 B.C. date for Layer 7 at Tarague, the only other radiocarbon date extending to the 2nd millenium B.C. comes from the site of Nomna Bay in south-eastern Guam. A radiocarbon age of 1,320 ± 170 years B.C. (GaK-1364) was obtained by Reinman (1977:39) for the 6"-12" level in Stratum I in Test Pit 6-1-1 at Nomna Bay. The chronological reversal of this date with the 880 ± 70 A.D. (GaK-1697) date obtained for the 12"-18" level in the same test pit presented interpretive difficulty.

The new geoarchaeological information from Tarague and existing data from Micronesia suggest that human colonization of the high islands of western Micronesia took place before the low islands or atolls. Though an age estimate of 4,000 B.C. - 2,000 B.C. has been given in the model advanced by Howells (1973) for the antiquity of human occupation on these high islands, the work at Tarague indicates a somewhat younger time frame. Since the incipient pre-Latte phase occupation layers at Tarague overlie Merizo limestone, the antiquity of other coastal sites on Guam, with similar geologic situations, is predicted to be younger than 3,000 B.C., the maximum age of Merizo limestone.

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REFERENCES

Bellwood, P. 1979 Man's conquest of the Pacific. Oxford University Press, New York.

Clark, J.G. 1977. World prehistory. Cambridge University Press.

Cloud, P., R.G. Schmidt, and H.W. Burke. 1956. Geology of Saipan, Mariana Islands. Part I. General Geology. Geological Survey Professional Paper 280-A. Washington, D.C.

Craib, J. 1983. Micronesian prehistory: an archaeological overview. Science. 219:922-927.

Easton, W.H., T.L. Ku, and R.H. Randall. 1978. Recent reefs and shore lines of Guam. Micronesica. 14(1):1-11.

Gifford, E.W. and D.S. Gifford. 1960. Archaeological excavations in Yap. Anthropological Records 18(2):149-224. Berkeley and Los Angeles. University of California Press.

Green, R. 1979. Lapita. In The prehistory of Polynesia (ed. J. Jennings), pp.27-60. Harvard University Press.

Hidikata, H. 1973. Some ceramics of Palau. Micronesian Area Research Center. Publication No. 2.

Howells, W.W. 1973. The Pacific Islanders. Peoples of the World Series. Vol. No. 16. Weidenfeld and Nicolson, London.

Intoh, M. 1982. The physical analysis of Pacific pottery. M.A. Thesis. University of Otago.

Leidemann, H. 1980. Intra-site variation at Ypao Beach, Guam: a preliminary assessment. Unpublished M.A. Thesis. University of Guam.

Libby, W. 1952. Chicago radiocarbon dates III. Science. 116:673-681.

Osborne, D. 1966. The archaeology of the Palau Islands: an intensive survey. Bernice P. Bishop Museum, Bulletin 230.

---------- 1979. 1968-1969. Archaeological test excavations, Palau Islands. *Micronesica* (Supplement 1, 1979).

Pellet, M. and A. Spoehr. 1961. Marianas archaeology: report on an excavation on Tinian. *Journal of the Polynesian Society*. 70:321-325.

Ray, E. 1981. *The material culture of prehistoric Taraque Beach, Guam*. Unpublished M.A. Thesis. Arizona State University.

Reinman, F. 1977. *An archaeological survey and preliminary test excavations on the island of Guam, Mariana Islands, 1964-66*. Micronesian Area Research Center.

Shutler, R. 1978. Recent radiocarbon dates and Oceanic prehistory. *Archaeology and Physical Anthropology in Oceania*. 13(2,3):215-228.

Solheim, W. 1968. The Batungan Cave sites, Masbate, Philippines. *Asian and Pacific Archaeology Series*. 2:21-62.

Spoehr, A. 1954. *Saipan, the ethnology of a war-devastated island*. Fieldiana: Anthropology 41:1-383.

--------- 1957. *Marianas prehistory*. Natural History Museum, Chicago.

Takayama, J. and M. Intoh. 1976. *Archaeological excavation of Latte site (M-13), Rota, in the Marianas*. Reports of Pacific archaeological survey No. 4. Hiratsuka: Tokai University.

Takayama, J. and T. Egami. 1971. *Archaeology on Rota in the Marianas Islands*. Reports of Pacific archaeological survey No. 1. Hiratsuka: Tokai University.

SOCIAL CHARACTERISTICS OF EARLY AUSTRONESIAN COLONISERS

Brian Hayden
Simon Fraser University

INTRODUCTION

Very little is generally written about the social characteristics of the earliest groups that colonized the islands east of Melanesia, although some authors occasionally reveal their assumptions about the matter in incidental statements (e.g. Bellwood 1979:255). I am specifically referring here to the social characteristics of Lapita communities and by extension to the social characteristics of all early Austronesian communities. Lapita, of course, was first defined and its importance in the initial occupation of Polynesia was recognized by Gifford and Shutler in 1956. Their insights have provided an unusually fertile basis for subsequent advances in our understanding of Oceanic prehistory. In this paper, I will argue that consideration of social characteristics can be a critical link to our understanding of why Lapita and Austronesian groups expanded so rapidly and over such long distances, as well as to our understanding of other important aspects of Oceanic prehistory.

THE MODELS

At the extremes, there are two alternative assumptions that can be made concerning the fundamental social characteristics of the original Lapita communities. First, it can be assumed that they were derived from egalitarian, or even status ranked, communities very similar to those found in many parts of New Guinea. This model is most consistent with the view sometimes proposed that Lapita groups expanded because they were swidden horticulturalists who "consumed" land at a rapid pace (Bellwood 1980:178; Kennedy 1981; White and Allen 1980:733).

The alternative is to view proto-Lapita and proto-Austronesian communities as being stratified in the form of incipient chiefdoms - or at least societies with inherent trends towards stratification - more or less similar to the chiefdoms of Polynesia at the time of contact.

In sum, the issue being raised is whether stratification evolved in Polynesia after the area was colonized, or whether tendencies toward social stratification were part of the cultural repertory originally brought into the area. If the view is adopted that stratification was brought into the area by the first migrants, then there are several problems to resolve. In the first place, if the original communities entering the area were stratified already, why did some of them subsequently undergo a reduction or loss of their stratification, while others maintained it? Sahlins (1958:248-50; Pawley 1981:19-20) has argued that this was due to unsuitable resource bases for maintaining chiefdoms on the smaller islands. However, if this is true, it must be asked what resources the larger islands had which were favorable to the maintenance of chiefdoms, if not for their emergence? Population levels and productivity here were similar to areas of New Guinea where no stratification emerged. Moreover, Peebles and Kus (1977:424-7) have pointed out that, contrary to Sahlins' model of the conditions under which chiefdoms should emerge, there is actually very little redistribution of raw materials, such as foodstuffs, which occurs in Polynesian chiefdoms. In fact almost all of the member communities in Polynesian chiefdoms either were self-sufficient in terms of food, or they traded directly with other communities for necessary materials without going through the chiefly bureaucracy. Under these conditions, even if Lapita communities had originated from stratified groups, what would have held them together? "Tradition" certainly does not seem to be a suitable explanation.

What I would like to argue is that in comparison to subsistence economies, economies involving significant trade of scarce and monopolizable resources are much more consistent with the assumption of originally stratified communities, and also that these types of trade economies are much more likely to leave archaeological sequences such as those found in Oceania.

EVALUATING THE MODELS

The Egalitarian Model

The assumption of egalitarian founding communities suffers from several major drawbacks. In the first place, Melanesia displays just as much geographical and ecological diversity, if not much more, as the rest of Oceania. Moreover, major parts of Melanesia were occupied vastly longer than the rest of Oceania and maintained comparable agricultural productivity with similar population densities. In spite of these apparently equally or even more favorable conditions for the emergence of social stratification (according to Sanders and Price 1968; Sahlins 1968; and others), it did not develop to any significant extent in Melanesia. If it did not develop in Melanesia from founding communities which can reasonably be assumed to have been egalitarian, why should it have developed anywhere else in Oceania? There are no obvious environmental conditions present in the rest of Oceania which are missing in Melanesia.

Secondly, the assumption of population pressure due to the consumption of land or stemming from an inherent population expansion does not adequately account for the extremely rapid expansion of the Lapita and subsequent Polynesian groups. Where groups are constantly coming up short of resources, they should be expected to curtail reproduction and survival to at least low levels, if not to equilibrium. Under these conditions, it is difficult to imagine any overall rate of population increase high enough to account for rapid population expansions such as that exhibited by Lapita and later Polynesian communities. Furthermore, if it is assumed that their inherent rates of increase were high, we are left wondering what people did after they ran out of islands to colonize. Moreover, the close correlation between population and resources documented for the recent past of the area (Hainline 1965) implies that populations which do not experience significant resource stress today are fairly well regulated. Why would this not have been the case prehistorically, especially since it could not have been known a priori at any particular time that there were or were not additional islands to colonize?

In sum, the egalitarian-founder model might be applicable to the initial colonization of Melanesia, with its slow rate of spread, and limited distances travelled. However, it seems difficult to apply it to the Lapita expansion.

The Stratificaton Model

The assumption of stratified or incipiently stratified founding communities is not without its problems as well. Before dealing with these, I would like to set out the strong points of this model.

Firstly, since social stratification did not develop in Melanesia even after many thousands of years of occupation, it seems unlikely that it would have developed in situ in the rest of Oceania after a much shorter period of occupation.

A second strong point for assuming that founding communities were already stratified to some degree is that socially stratified societies tend to generate expansive population movements, even where the overall rate of population growth is relatively low. These migrations come about due to the tendency of members of the upper classes to acquire numerous wives and concubines, who produce more offspring than can be accommodated in the upper class bureaucracy. This situation, for example, reached chronic proportions in China at the time of Confucious, who was himself a "poor" aristocrat. Examples of similar situations can be found in the history of Europe, and appear to have affected such groups as the Itza Maya (Carmack 1981). One common solution to this situation has been to equip lower ranking nobles who feel that they have been cheated of their rightful economic inheritance with the means to go out and establish themselves in new domains, by conquest if necessary. If this does not occur, fighting often breaks out within noble lineages, and the loosing factions are forced to submit or flee, either to conquer new territory, or to discover uninhabited lands. Polynesian oral history is replete with such episodes. Whether "poor" nobles leave willingly or are forced out in feuds, the result in terms of out-migration is the same. Where there is unoccupied land or inhabitants who cannot defend themselves effectively, this leads to surprisingly rapid population spreads. In fact, it often happens that the emigrating groups are composed primarily of male warriors or those wishing to control the means of production, who succeed for a time in establishing their authority over subjugated groups, but who in the long term lack sufficient numbers or enough women to maintain either their genetic or their linguistic coherence. They are forced to intermarry with local inhabitants and to deal with them on an intensive basis. This pattern has been well documented for the Mexican Itza who conquered Maya groups (Carmack 1981:44-55) and subsequently lost their linguistic and social distinctiveness. This process accounts very well for the hodge-podge of linguistic, racial, political, and material patterning that characterizes the areas where Lapita groups settled and where there were already well established populations, as in Melanesia (see Dutton 1978 for examples of Austronesian absorption). Pawley (1981) has recently argued this same point using linguistic and political structure data for Austronesian groups.

As I noted previously, the major difficulty with this model is that no one has proposed an adequate basis for the evolution or maintenance of stratified communities. In Oceania, the social and population pressure models of chiefdom development fail completely as explanatory frameworks since they do not account for the lack of chiefdoms in New Guinea. Economic models, however, are potentially much more productive given some modification. According to the most prevalent archaeological theory (Sanders and Price 1968; Harris 1971; Sahlins 1968; Gilman 1981), chiefdoms imply control over important resources by a small proportion of the population. The only problem is in identifying important resources that could have been effectively controlled by incipient or established elites. At first there seem to be no such resources which everyone would not have had adequate access to, or which they could not have obtained via individual exchange, as in New Guinea (Peebles and Kus 1977). However, closer examination of the situation reveals that archaeologists have overlooked a relatively important item, in a manner reminiscent of the Polish customs agents who stopped the same man daily for 20 years and vigorously searched through his wheelbarrow of straw. They were convinced he was smuggling something, but were never able to catch him with anything. When he finally retired, they said to him, "Stanislaus, we know that you were smuggling things during these past 20 years, now that you are retired, won't you tell us what it was?" "Sure," said Stanislaus, "Wheelbarrows!"

Similarly, I would suggest that boats are the key to understanding the problem of stratification in Polynesia. I am not referring to all classes of boats, but to boats capable of reliably and repeatedly making trips of several hundred or thousand kilometers in the open ocean. In order to construct such boats, large amounts of labor and materials had to be assembled. The construction of a single medium-sized long-distance canoe took about one to three years (Ferdon 1981:244; Dodd 1972:100). In addition, the labor had to be highly skilled. As a result, canoe builders were full-time specialists trained through a rigid system of apprenticeship and they occupied elevated social positions (Thompson and Taylor 1980:21). This indicates the key role they played in sustaining the power of the elites. Similarly, sail makers, wood carvers, and rope makers for boats had relatively high status, sometimes approaching the level of village chiefs (ibid). Underwriting the construction of such boats, and chiefs often owned several, might well be compared to the capital and labor required to establish a factory in the Industrial World. In fact, the paramount chief in Tahiti is described as maintaining a regular dockyard (Ferdon 1981:240). Average individuals would find the task of building such boats almost insurmountable, and cooperative ventures would be unlikely to succeed due to the magnitude of the task and the high potential for disputes over the many important decisions that had to be made not only in building the boats, but in sailing them and managing the economies of long-distance transactions as well.

Large, long-distance boats cannot be built and sailed safely and effectively without clearly defined hierarchies of command and responsibilities. It would require individuals of considerable wealth and power to successfully complete these construction projects, not to mention maintaining the sailing enterprises with skilled navigators and repairmen as noted by early observers (Dodd 1972:138, 159; see also Haudricourt 1962:46-8). It is no coincidence that these boats were captained by chiefs and priests on war, trading, and exploratory expeditions (Thompson and Taylor 1980:5; Dodd 1972:138). Thus, construction, ownership, and the sailing of long-distance boats, I would argue, was probably one of the keys to the maintenance and perhaps to the origin of the unusually strong social stratification on islands occupied by Lapita and Polynesian groups. On the other hand, as Sahlins (1958) has argued, where population levels dropped below certain critical limits, such as on small atolls, it might prove difficult to maintain rigid stratification.

However, the proposition that ownership of long-distance boats sustained, and/or created Oceanic social stratification still leaves unanswered the question as to why such boats were important. Few prehistorians doubt that such boats must have existed right from the outset of the Lapita migrations, for there is a considerable body of evidence indicating that even early Lapita communities maintained continuing contacts with widely dispersed areas, including other Lapita communities (Dickinson and Shutler 1974, 1979:1658; Green 1975; Bellwood 1979:247-8; White and Allen 1980-732; Kennedy 1981), while the Proto-Austronesian language contained terms for outrigger seagoing canoes (Pawley and Green 1973; Bellwood 1980:178), and Proto-Oceanic contained terms for "chief" and "commoners" or "subjects" (Pawley 1981:14-18). What would have induced members of these communities to undertake voyages requiring tremendous outlays of energy and materials, involving considerable risks? From a cultural materialist perspective, I would argue that both the construction of large boats and the undertaking of long voyages entail major outlays of time and effort. The persistent patterns of long-distance contacts documented for Lapita groups must have more than repaid the initial investments for those underwriting the projects. The only reasonable activity which is likely to have generated such a surplus over the initial investment would have been trade. I do not refer to local, relatively unrestricted exchange of foodstuffs or other local resources, such as occurred in much of Melanesia. Given the limited capacities of boats, and the relatively abundant food staples that existed within the Oceanic sphere, it seems dubious that the Lapita voyagers were exchanging common staples. Rather, it is likely that they were purveyors of highly access-restricted, unusual goods - primitive valuables, or specialty items - which high ranking individuals would be willing to pay high prices for.

While Green (1974:257; 1976:245) and others have argued for Lapita as a culture based on the economic specialization of long-distance trade, this view has recently been challenged by White and Allen (1980:733) and modified by Green himself. What I wish to argue is that the view of Lapita as significantly, but not entirely, based on a long-distance economic trade specialization still is the most powerful explanatory model available. Such a view accounts for the maintenance of stratification where sufficient population existed to support it. It places the elites in the position of monopolistic ownership of the means of acquisition for a very important segment, although far from the only segment, of the economy. It is consistent with the shoreline locations of the vast majority of Lapita sites, and with the relatively large nucleated Lapita sites, of sizes which tend to characterize trading and manufacturing communities (e.g. see Hayden 1978). It is consistent with the frequent occurrence of various types of ornaments (primitive valuables) in Lapita sites, including the very elaborate Lapita ceramics, shell rings, shell bracelets, pig tusks, shark teeth and bone pendants, pearl shell disks, human skull tablets, tattooing chisels, round stone gaming disks, adzes made of rare rock types, obsidian and other unusual rocks as well as unusual fauna such as wallabies, plus an unknown number of perishable organic artifacts made of wood, fiber, cloth, skins and feathers. In fact, if my basic arguments are correct, I predict that a substantially greater and richer array of primitive valuables will be found in Lapita sites as more and more are excavated. Most importantly, however, is the fact that highly profitable long-distance trade would certainly provide one of the strongest positive inducements known for daring explorations and colonizations of unknown areas of the world. And in the Polynesian context, intentional exploration of Oceania makes much more sense than colonization due to accidental voyages because the dominant winds and currents come from the east, making it unlikely that any but the most determined sailors would travel from west to east.

In fact, I would argue that traders looking for new sources of primitive valuables, which could be exchanged to elites at considerable profit, provide a consistent pattern of rapid expansion and colonization throughout the world. Examples can be taken from the early sea traders who penetrated all the major rivers along the eastern seaboard of North and South America within a few years of Columbus' first voyage. Nor should it be forgotten that Columbus' entire daring trip toward the 'edge' of the world was for the same purpose, especially for spices. There were also the fur-traders who penetrated the most desolate parts of the boreal forests of Canada. There were the traders of the Classic world who penetrated into the heart of the barbarian Celtic domain; there were the Phoenicians; and there were the Mesoamerican Pochteca. In all these cases, the possibility of substantial profits from trade (not necessarily in terms of cash) often drove some individuals to take extreme risks and to explore every square kilometer within their reach for the sake of gaining potential profit. Moreover, they often established colonies, initially for the purpose of exploiting tradeable resources, and subsequently for the purpose of using the subsistence potentials of the areas. White and Allen's (1980) and Kennedy's (1981:758) arguments that no populations existed in Oceania to trade with (therefore Lapita voyages were not traders) ignore the following facts: (1) that Lapita traders could not have known that Polynesia was uninhabited; (2) that traders can exploit tradeable resources themselves if there are no indigenous populations, just as Tahitians traveled to small, uninhabited atolls to procure rare feathers (Ferdon 1981:225); and (3) that traders operating from home bases with mixed (subsistence/trading) economies would be on the lookout for more favorable locations to farm and locations less susceptible to predation from other traders. Thus, even though Lapita voyagers were motivated by economic trade incentives to explore the Pacific, these motives would have led to colonization and expansion, with new settlements becoming permanent parts of the trade network. Thus, trade and wealth were the motivating factors, while ownership of boats capable of transporting cargo long distances resulted in restricted access to this wealth and kept its control among a small elite.

If the Lapita groups were purveyors of the unusual for Melanesian or other high status individuals seeking ways to display their status, the rest of Oceanic prehistory follows logically. Given an initial familiarity with water transport, such traders not only would drive themselves to develop better and further-ranging water craft, but they would also drive themselves to explore new areas and set up new stations or settlements, not only in Oceania, but in every accessible corner of the surrounding ocean. Because the manpower to build boats, ship goods over long distances, defend trading parties, and raid competitors meant the key to success, it is not surprising that elites attempted to maximize their supporting populations by various irrigation, terracing and other intensive agricultural projects.

It is probably not important that little evidence of such trade exists in many sites. Primitive valuables often center on exotic species of plants, birds or animals, leaving few or no remains archaeologically. In Mesoamerica, Voorhies (1982:88,90) has noted that demand for lowland plant and animal products was ubiquitous and strong. She lists over 150 items of export value such as cacao, oils, spices, dyes, pelts, fibers, medicines and numerous feathers, and observes that they are almost all "invisible" archaeologically. The parallels to the situation in Melanesia are particularly striking. In North America, other archaeologically invisible products such as furs and tobacco were among the most important. In early coastal China, the exotic bird feathers of Melanesia and various culinary or medicinal items might well have rendered many a risky trip more than worth while. In Polynesia, trade often involved such items as coconut oil, special fish sauces, cloth, fibers, pearls, white dog hair, special feathers, shells, and wooden bowls, most of which were only for elite and elite-affiliated use (Ferdon 1981:225). Utilitarian items such as the adzes so necessary in canoe building must have also brought high prices.

No matter why certain items confer upon their holders special status, while other items perhaps equally as rare or attractive do not, it is nevertheless true that once social groups recognize classes of items as indicating wealth or power or prestige, it is possible to motivate large segments of every population to work assiduously to procure them. Many of the supporters of the Lapita and derivative elites probably would have been rewarded with such items, just as today individuals often work at considerable length to obtain rare minerals, attractive clothes, and a diverse array of crafted or raw rare metals. Polynesian chiefs certainly did everything in their power to impose forcibly their trade monopolies on the seas, including the systematic plundering of all unauthorized foreign or non-official trading canoes (Ferdon 1981:226). In both the Oceanic and Western Industrial cases, such items were fungible in certain contexts and could be exchanged in one way or another for more basic requirements of survival (Hughes 1977:208).

Once the traders of primitive valuables extended their range of operations beyond a certain limit, it would probably have been most economical to establish relays and middlemen in the chain of procurement. Extended far enough, some of these links in the chain might never know where the ultimate consumers of trade goods were located. The extension of such a trade chain would also open up additional markets of more local character, although possibly not as profitable. Local consumers in Melanesia would have included the Big Men of the Papuan communities. As Green (1974) has suggested, a further implication of this model is that some links in the far-flung trade chains would be much less connected to the central channels of trade than others, whether due to dis-economies of very great distances and greater travelling risks, or due to relatively impoverished sources of high-demand primitive valuables in certain areas. Such marginal communities might end up relying on trade to only a very limited extent in their overall economic strategies, although the possibility of establishing new lines of commerce would always motivate groups to maintain contacts with surrounding groups, and to underwrite occasional exploratory voyages. In these most marginal areas if there were no indigenous consumers, elites would either end up trading with the nearest elites on other islands, or if there were pre-existing local populations, as at Mailu and Motupore in Papua, they would adopt trading economic specializations. It is highly significant that in the cases of Mailu and Motupore, social stratification was closely associated with long-distance trade (Irwin 1974). Although occupation of these locations may postdate the Lapita expansion, they still share a common Austronesian heritage. In fact, it is possible that when more is known of the initial Austronesian expansion, mechanisms similar to the ones suggested for the Lapita expansion in Oceania may prove to have been important as well. For instance, one currently popular scenario is to view Austronesians as originating in coastal southern China, subsequently expanding to Taiwan, the Philippines, Indonesia and Melanesia (Shutler and Marck 1975; Brace and Hinton 1981). While very early (ca. 9,000 B.C.) expansions may have been slow and based on population pressure or need for more agricultural land, once elites or at least big men had emerged in southern China, trade in exotics would have become profitable between the mainland, Taiwan, and islands further down the chain. Although small community size and the subsidiary role that trade played in the overall economy may have moderated stratification tendencies at first, it can be suggested that these would have become fully developed wherever trade was maximally profitable and wherever relatively larger populations could be supported.

If early Austronesians developed strong tendencies toward stratification by trading restricted-access goods to elites in coastal China, it may be no coincidence that elite succession systems and mythology in coastal China and Polynesia bear some strong resemblances, but contrast with those in Melanesia (Pawley

1981; Chang 1980; Young 1982). And it certainly seems far from coincidental that Austronesian languages were used as long-distance trading languages even by non-Austronesians in some parts of Melanesia (Dutton 1978), whereas indigenous dialects were apparently adequate for local exchange.

The model, as I have extended it, is almost entirely an economic and cultural materialist model. It accounts more succinctly than any of the other alternatives for a large number of characteristics of the Lapita expansions, and may be relevant to the Austronesian expansions as a whole. It is consistent with the archaeological data, with the ethnographic data, with the physical anthropological data, with the linguistic data, and perhaps most importantly with the values of Polynesians at the time of contact. These were values which sanctioned the elite monopoly of trade on the high seas, which held chiefs to be semidivine, and which actively promoted expansion and conquest.

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REFERENCES

Bellwood, Peter. 1979. Man's conquest of the Pacific. Oxford University Press, New York.

--------------- 1980. The peopling of the Pacific. Scientific American. 243(5):174-185.

Brace, C.L. and R.J. Hinton. 1981. Oceanic tooth-size variation as a reflection of biological and cultural mixing. Current Anthropology. 22:549-69.

Carmack, Robert. 1981. The Quiche Mayas of Utatlan. University of Oklahoma Press, Norman.

Chang, Kwang-chih. 1980. Shang civilization. Yale University Press, New Haven, Conn.

Dickinson, W. and R. Shutler. 1974. Probable Fijian origin of quartzose temper sands in prehistoric pottery from Tonga and the Marquesas. Science. 185:454-457.

Dickinson, W. and R. Shutler Jr. 1979. Petrography of sand tempers in Pacific island potsherds. Geological Society of America Bulletin. 90, Pt 2:1644-1701.

Dodd, Edward. 1972. Polynesian seafaring. Dodd, Mead and Co., New York.

Dutton, Tom. 1978. Language and trade in central and south-east Papua. Mankind. 11:341-353.

Ferdon, Edwin. 1981. Early Tahiti as the explorers saw it. University of Arizona Press, Tuscon, Arizona.

Flannery, Kent. (ed.) 1982. Maya Subsistence. Academic Press, New York.

Gifford, E.W. and R. Shutler Jr. 1956. Archaeological excavations in New Caledonia. Anthropological Records 18:1. University of California Press, Berkeley.

Gilman, Antonio. 1981. The development of social stratification in Bronze Age Europe. Current Anthropology. 22:1-14.

Green, Roger. 1974. Sites with Lapita pottery: importing and voyaging. Mankind. 9:253-259.

------------ 1975. Polynesian voyaging. Science. 187:274.

------------ 1976. Lapita sites in the Santa Cruz group. In Southeast Solomon Islands cultural History (eds R.C. Green and M.M. Cresswell), pp. 245-65. Royal Society of New Zealand Bulletin 11.

Harris, Marvin. 1971. Culture, man and nature. Crowell, New York.

Hainline, Jane. 1965. Culture and biological adaptation. American Anthropologist. 67:1174-1197.

Haudricourt, André. 1962. Domestication des animaux, culture des plantes et traitment d'autrui. L'Homme. 2(1):40-50.

Hayden, Brian. 1978. Bigger is better?: factors determining Ontario Iroquois site sizes. Canadian Journal of Archaeology. 2:107-116.

Hughes, Ian. 1977. New Guinea stone age trade. Terra Australis 3. Department of Prehistory, Research School of Pacific Studies, Australian National University, Canberra.

Irwin, Geoffrey. 1974. The emergence of a central place in coastal Papuan prehistory: a theoretical approach. Mankind. 9:268-272.

Kennedy, Jean. 1981. Lapita colonization of the Admiralty Islands? Science. 213:757-9.

Pawley, Andrew. 1981. Rubbish-man, commoner, big-man, chief? Linguistic evidence for hereditary chieftainship in Proto-Oceanic society. Draft of a paper to appear in a Festschrift for Aarne Koskinen. On file with the author: University of Auckland.

Pawley, Andrew and Roger Green. 1973. Dating the dispersal of the Oceanic languages. Oceanic Linguistics. 12:1-67.

Peebles, Christopher and Susan Kus. 1977. Some archaeological correlates of ranked societies. American Antiquity. 42:421-448.

Sahlins, Marshall. 1958. Social stratification in Polynesia. University of Washington Press, Seattle.

________________ 1968. Tribesmen. Englewood Cliffs, N.J.: Prentice-Hall.

Sanders, William and Barbara Price. 1968. Mesoamerica. Random House, New York.

Shutler, R. and J.C. Marck. 1975. On the dispersal of the Austronesian horticulturalists. Archaeology and Physical Anthropology in Oceania. 10:81-113.

Thompson, Judi and Alan Taylor. 1980. Polynesian canoes and navigation. Institute for Polynesian Studies, Laie, Hawaii.

Voorhies, Barbara. 1982. An ecological model of the early Maya of the Central Lowlands. In Flannery 1982:65-95.

White, J. Peter and Jim Allen. 1980. Melanesian prehistory: some recent advances. Science. 207:728-734.

Young, L.M. 1982. The Shang of ancient China. Current Anthropology. 23:311-314.

ARCHAEOLOGY AT NAN MADOL, PONAPE

William S. Ayres
University of Oregon

Recent research on Ponape, Eastern Caroline Islands of Micronesia, has produced archaeological evidence for formulating a cultural historical sequence and for examining the development of local chiefdoms. The prehistoric evolution of complex socio-political organization is revealed in archaeological remains because stone architecture reflects relative structural units within the political system. The most impressive example of this relationship is the massive coastal site of Nan Madol, which represents the end point of a trend in political centralization reflected by megalithic architecture. Considerable ethnographic and ethnohistoric data (e.g. Riesenberg 1968, Bernart 1977) substantiate Nan Madol's position as the preeminent political and religious center on the island. Bernart's (1977) traditional three-fold sequence for early Ponapean cultural development provides a general model that is being tested using archaeological and other historical data (Fig. 1).

Nan Madol (Fig. 2) is a complex archaeological district built up on the coastal reef flat near small Temwen Island on the east coast of Ponape. The site core is enclosed by a wall 1.5 km long by 0.5 km wide and it contains nearly 100 major architectural units (stone and coral fill platforms or artificial islets). This area served as the main residential and ritual center for the highest ranking members of the society. According to oral traditions, the site was the seat of the Sau Deleur dynasty which united all of Ponape's estimated 25,000 people in later prehistoric times. The dynasty was overthrown by invaders reportedly from Kosrae (Kusaie), 480 km to the east.

Despite Nan Madol's obvious cultural and historical significance, very little archaeological work has been done there. European visitors had described aspects of the site in the early nineteenth century, but the first detailed map was drafted by the German ethnographer Hambruch in 1910 (Hambruch 1911, 1936). Of a number of minor excavations undertaken since the early 1800's, mostly in the site's largest tombs, only one provided accurate occupation dates (the 1963 Smithsonian project produced radiocarbon readings between A.D. 1200 and 1400 for cooking fires on one stone platform called Idehd). Two historic preservation surveys were done at the site in the late 1970's (Saxe et al. n.d., Athens 1980). Athens verified the presence of surface pottery which was originally reported by visitors in the early 1800's (Athens 1981:17).

No archaeological work, other than brief reconnaissance surveys, had been conducted on the main island of Ponape before the author began research there in 1977. As a result of this latter

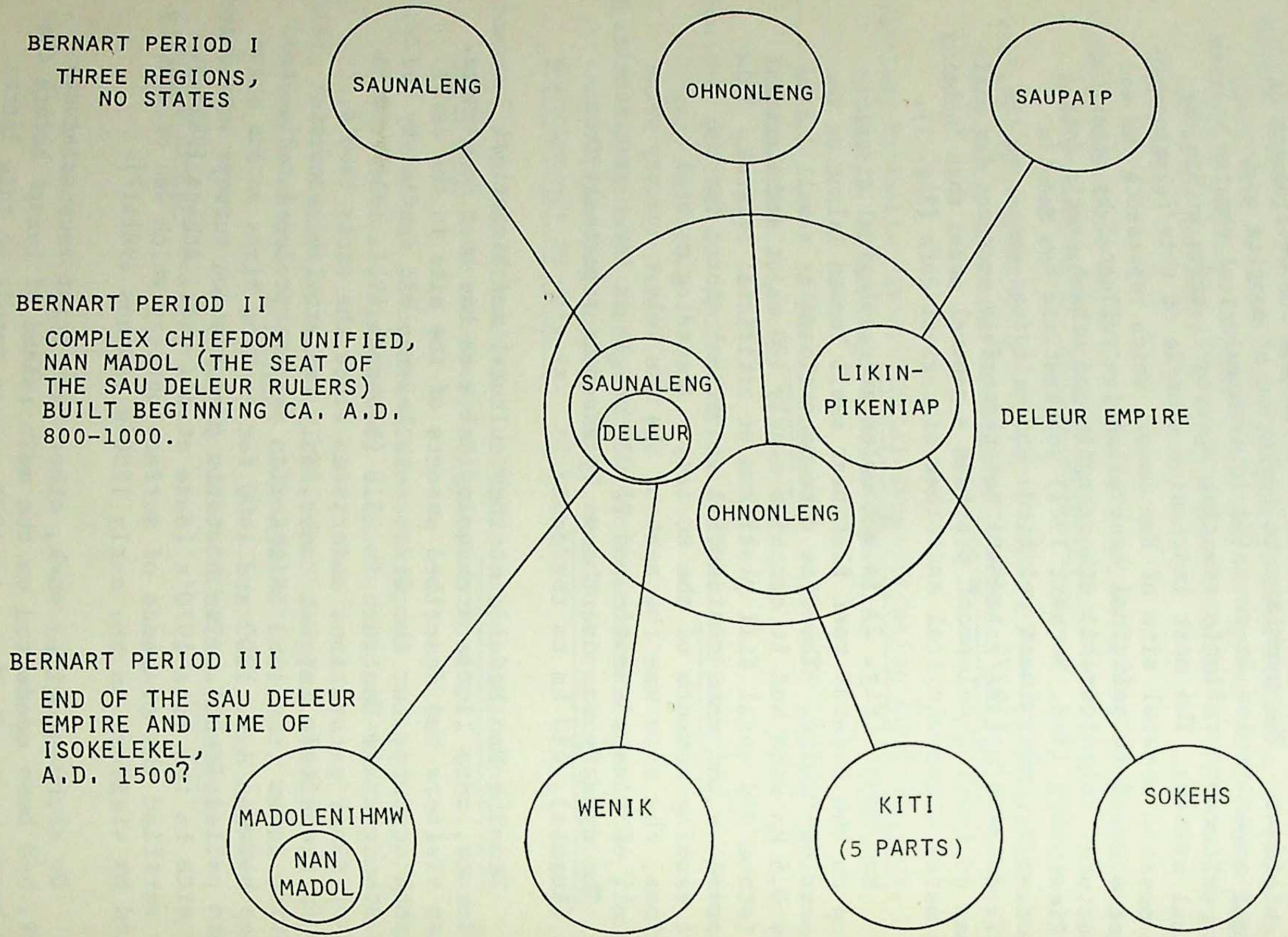

Figure 1. A Model of Political Relationships Among the Major Segments of Earlier Ponapean Society According to Oral Traditions and Archaeological Evidence.

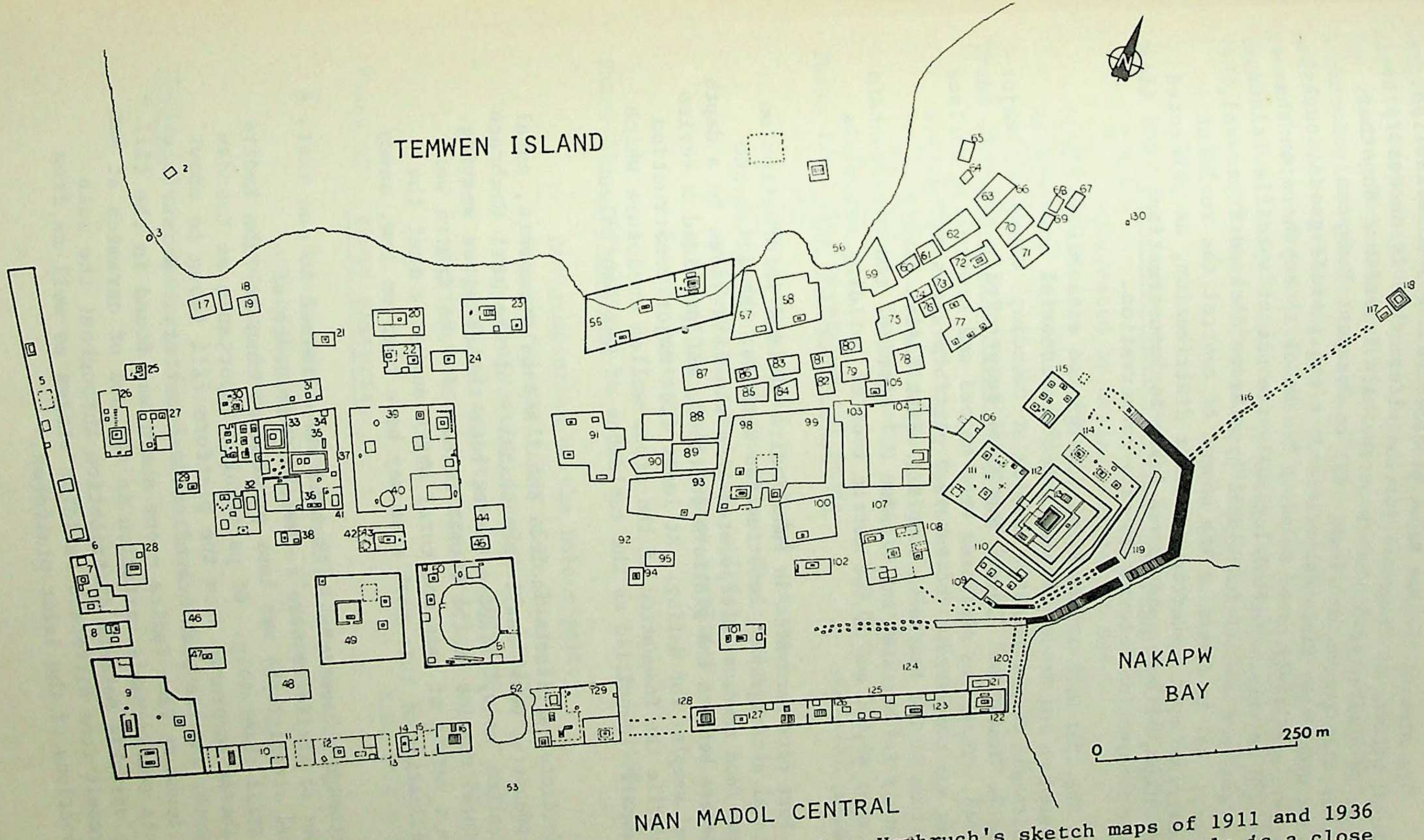

Figure 2. Plan of the Nan Madol Central architecture based on Hambruch's sketch maps of 1911 and 1936 as modified in Sketch No. 328 of the Ponape Lands and Surveys Office; the scale is a close approximation for most of the site except the Nan Dauas tomb (No. 113), which Hambruch drew about 1.5 times larger than its actual size relative to islets such as Pahn Kadira (No. 33-36).

The aims of the Nan Madol project are: (1) to establish a cultural historical framework for the site; this is necessary to relate it to similar developments on the main island and on other islands in the Eastern Carolines; (2) to document Ponapean relations with other Micronesian islands - e.g., trade goods, such as pottery, are likely to be found at Nan Madol if anywhere on the island; (3) to examine archaeologically the use of specific islets and platforms and to test functional hypotheses derived from oral traditions; (4) to determine the amount of control the resident chief exercised over resources and their distribution, as reflected in trade items, tribute, and corvee labor for construction; and (5) to gather information relevant to site conservation.

The 1981 work at Nan Madol (designated site MiECPo C3-1) concentrated on and around the Sau Deleur residential compound at Pahn Kadira and on the priestly complex at Usendau; these are major platforms in "Lower" and "Upper" Nan Madol respectively (Fig. 2, No. 33 and 104). These two platforms were mapped and controlled surface collecting was completed. The recorded platform sizes illustrate the magnitude of the Nan Madol complex; Pahn Kadira covers approximately 1.3 hectares and Usendau 0.7 hectare, and they contain somewhat over 40,000 and 20,000 metric tons of building materials respectively.

Four pits excavated in Pahn Kadira yielded information on architectural stratigraphy, construction methods, shellfish and animal bone food remains incorporated into the fill (down to a depth of 1.65 meters beneath the platform surface), and provided a series of charcoal samples for dating. At least five major construction levels underlie the foundation of the stone-walled enclosure which is traditionally identified as the residence of the Sau Deleur chief.

Collected artifacts include shell adzes, ornaments, coral and stone pounders, pearl shell lure shanks - of the sort Hambruch (1936:51) called "money" - and a carved bone thatching or weaving tool. Cultural remains at the lowest levels of Pahn Kadira were embedded in a matrix of sand and coral which suggests that the initial utilization of this reef area may have been on low, sandy islets.

Although excavations in Usendau were limited to one test, a larger number of artifacts were recovered. Evidence of architectural stratigraphy was less pronounced than in Pahn Kadira but it was still observable. Of particular importance at Usendau are the potsherds recovered from the platform fill (down to about 1.1 meter depth) and the presence of surface pottery. No surface pottery was found at Pahn Kadira - one sherd was found in the fill - which suggests considerable variation in the use of ceramics at Nan Madol. This variable pottery distribution throughout the site appears to result from different building stages as well as from different functions of the islet platforms.

effort, artifact sequences and a detailed architectural classification system have been developed; these will pave the way for placing Nan Madol within a broader, island-wide context. An archaeological phase sequence (Table 1), community organization models, and a political evolution outline formulated in this research are based on records of over 200 surveyed sites, test excavations, and 18 radiocarbon dates (Ayres 1979, Ayres and Haun 1980, Ayres, Haun and Severance 1981, Ayres and Haun n.d.).

Phase I	Settlement and Adaptive Integration	pre 500 B.C.-A.D. 0	Suggested by evidence of inland forest clearance ca. 500 B.C. (Ayres, Haun, and Severance 1981:119, Fig. 40).
Phase IIA	Early Developmental Phase	A.D. 0 - A.D. 800	Initial evidence of communal breadfruit pit storage, stone platform house foundations; pottery present.
Phase IIB	Late Developmental Phase	A.D. 800 - A.D. 1500	Construction of Nan Madol and the appearance of the Deleur Empire; large residential complexes, chiefly residential architecture, stylized tombs, pottery.
Phase III	Dissolution	A.D. 1500 - A.D. 1826	Disintegration of the Deleur polity; Nahnmwarki title for high chiefs; large residential complexes, chiefly residential architecture, stylized meeting houses; pottery no longer in use.
Phase IV	Early Historic	A.D. 1826 - A.D. 1885	Continuation of Phase III features and elaboration of the "U"-shaped meeting house form.

Table 1: Ponapean Cultural Historical Outline.

Recent radiocarbon readings from these excavations indicate that the initial construction of Usendau began in the late 700's A.D. and that of Pahn Kadira began perhaps 200 years later. The most recent dated structural addition to Pahn Kadira was made after A.D. 1400 and pottery appears not to have been in use this late.

The Nan Madol pottery and that from the Awak Valley Peinais site (MiECPo B7-143) - which has plain red-brown ceramics dated to 1500 BP (Ayres and Haun n.d.) - are of particular interest because the distribution of pottery in the western Pacific has long been a subject of archaeological concern. New explanations for early Micronesian settlement and the development of local technological systems - which, through time, became less reliant on pottery containers - must be developed taking into consideration the new archaeological data from the area. Reformulations of linguistic relationships among the various Micronesian settlements (Grace 1968, Shutler and Marck 1975) have contributed quite a different view from those offered by earlier scholars such as Buck (1938) for the origins of the eastern Micronesian settlers. The prehistoric pottery technologies of the area that are just now becoming known archaeologically should provide a way to test the linguistic reconstructions. It is now clear that prehistoric pottery manufacture was widespread throughout the Micronesian high islands (probably including Kosrae also, although no pottery has been found there yet).

Truk, geographically the closest to Ponape, has pottery similar to that found at Nan Madol and in Awak; however, the Ponapean pottery is thinner and has less elaborate rim forms and the earlier ware lacks the white, web-like stripes and high (30-50%) calcareous sand temper of the Trukese pottery (Shutler, Sinoto and Takayama n.d.). Rim lip notching and construction details of the Ponapean pottery suggest a S.E. Melanesian-West Polynesian Lapita origin for the early eastern Micronesian settlers. Although the present Ponape ceramic collections are limited in size, they do provide an important new body of evidence for comparative studies of Micronesian pottery.

Other Nan Madol artifact comparisons (e.g. of prestige items such as shell arm bands, beads, and other ornaments) and rank-related stone architectural similarities (e.g. in tombs) are expected to be useful in defining the status of the resident chiefs of the complex relative to others on the island. Also, estimates of construction costs in terms of time, personnel, and materials will give a concrete basis for comparison of "public works" projects undertaken at various chiefly levels. For example, the largest stone tomb (lolong) located during intensive survey of Awak Valley contains about 220 m^3 of basalt, principally columnar prisms (Ayres, Haun and Severance 1981:25-26); the largest tomb constructed at Nan Madol, the Nan Dauas enclosure, contains roughly 4500 m^3 of basalt and 13.500 m^3 of coral fill. Estimated weights of the transported building materials are just over 600 metric tons for the Awak tomb and over 45,000 metric tons for the Nan Dauas tomb.

Because the chiefly hierarchy is an important mechanism through which access to land is regulated on people-rich but resource-poor Pacific islands, determining Nan Madol's position within the broader Ponapean and Micronesian setting will aid in defining general relationships among population growth, sociopolitical integration, and resource distribution.

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REFERENCES

Athens, J. Stephen. 1980. Archaeological investigations at Nan Madol: islet maps and surface artifacts. Pacific Studies Institute, Guam.

------------------ 1981. The discovery and archaeological investigation of Nan Madol, Ponape, Eastern Caroline Islands: an annotated bibliography. Micronesian Archaeological Survey Reports No. 3. Historical Preservation Office, Saipan.

Ayres, William S. 1979. Archaeological survey in Micronesia. Current Anthropology. 20(3):598-600.

Ayres, William S. and Alan E. Haun. 1980. Ponape Archaeological Survey: 1977 research. Micronesian Archaeological Survey Reports No. 1. Historic Preservation Office, Saipan.

---------------------------------- n.d. Ponape settlement archaeology. Report 79-2. Ponape Archaeological Survey. Submitted to the Historic Preservation Office, Saipan, 1980. In press.

Ayres, William S., Alan E. Haun and Craig Severance. 1981. Ponape Archaeological Survey: 1978 research. Micronesian Archaeological Survey Reports No. 4. Historic Preservation Office, Saipan.

Bernart, Luelen. 1977. The Book of Luelen. Translated and edited by J.L. Fischer, S. Riesenberg, and M.F. Whiting. (Pacific History Series 8). University of Hawaii Press, Honolulu.

Buck, Peter. 1938. *Vikings of the Sunrise*. J.B. Lippincott, New York.

Grace, George. 1968. Classification of the languages of the Pacific. In *Peoples and cultures of the Pacific* (ed. A.P. Vayda), pp. 63-79. American Museum of Natural History, New York.

Hambruch, Paul. 1911. Die Ruinen von Ponape. *Korrespondenzblatt für Anthropologie, Ethnologie und Urgeschichte*. 42:128-131.

—————— 1936. Ponape: Die Ruinen. In *Ergebnisse der Sudsee Expedition 1908-1910* (ed. G. Thilenius). II.B.vii. Vol. 3. Friederichson, DeGruyter, Hamburg.

Riesenberg, Saul. 1968. The native polity of Ponape. *Smithsonian Contributions to Anthropology* Vol. 10. Smithsonian Institution Press, Washington.

Saxe, Art, Richard Allenson, Susan R. Loughridge. n.d. The Nan Madol area of Ponape: researches into bounding and stabilizing an ancient administrative center. Final report submitted to the Historic Preservation Office, Saipan, 1980.

Shutler, Richard and Jeffery Marck. 1975. On the dispersal of the Austronesian horticulturalists. *Archaeology and Physical Anthropology in Oceania*. 10(2):81-113.

Shutler, Richard, Yosihiko Sinoto, and Jun Takayama. n.d. Fefan Island survey and mitigation project. Report submitted to National Park Service. National Technical Information Service, Washington.

CARIES FREQUENCY IN DECIDUOUS DENTITIONS OF PROTOHISTORIC EASTER ISLANDERS

Douglas W. Owsley[1]
Ann Marie Mires[1]
George W. Gill[2]

INTRODUCTION

Dental pathology studies of prehistoric and early historic populations have found the deciduous dentition to be less prone to caries than were permanent teeth of the same series (Brabant and Brabant 1962; Wells 1975). Consequently, dental decay is considered predominantly an adult disease in early groups. In populations dependent upon agriculture, however, dental decay often affected both adults and children. Agriculturally derived subsistence diets, rich in carbohydrates, promote an oral environment conducive to dental decay (Turner 1979).

Recent examination of a late prehistoric-early protohistoric (ca. A.D. 1700) skeletal sample from Easter Island showed a high percentage of permanent teeth affected by caries (Owsley, Mires and Gill n.d.). This archaeological series represents a self-sufficient island community whose horticultural subsistence economy is ethnographically described (Metraux 1940).

This study determined whether deciduous dentitions of the Easter Island collection were similarly affected by caries. Frequency of dental decay was determined by tooth type. An ethnohistoric approach was used to relate the frequency of carious teeth to foods available to the islanders. Data for children were contrasted with values for early continental European populations for comparative perspective.

Methods

A total of 121 deciduous teeth from 23 individuals were available for examination. This sample is part of the collection recently established by the 1981 Easter Island Anthropological Expedition (Gill 1981), and is curated at the Easter Island Museum, Easter Island, Chile.

Data were tabulated by individual and on a per tooth basis. The presence of at least one lesion on an erupted tooth determined coding as carious. Ages of children were determined using the tooth eruption standards of Schour and Massler (1944), and the Johnston (1962) standards for longitudinal bone growth. The patterning of lesions by tooth type was quantified to delineate which teeth were prone to caries at each age.

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[1] Department of Geography & Anthropology, Louisiana State University
[2] Department of Anthropology, University of Wyoming

	.5 - 2.5 yrs			2.5 - 4.5 yrs			4.5 - 9 yrs			10 - 14 yrs		
Maxilla	#	C	%	#	C	%	#	C	%	#	C	%
I_1	1	0	0.0	3	0	0.0	2	0	0.0	0	0	0.0
I_2	0	0	0.0	3	1	33.3	2	0	0.0	0	0	0.0
C	2	0	0.0	3	0	0.0	2	0	0.0	0	0	0.0
M_1	3	0	0.0	4	2	50.0	9	0	0.0	1	0	0.0
M_2	2	0	0.0	4	0	0.0	11	4	36.4	1	0	0.0
Total	8	0	0.0	17	3	17.6	26	4	15.4	2	0	0.0
Mandible												
I_1	4	0	0.0	5	0	0.0	2	0	0.0	0	0	0.0
I_2	0	0	0.0	4	0	0.0	2	0	0.0	0	0	0.0
C	3	0	0.0	4	1	25.0	3	0	0.0	0	0	0.0
M_1	7	2	0.0	7	3	42.9	6	2	33.3	0	0	0.0
M_2	5	0	0.0	8	3	37.5	6	2	33.3	2	1	50.0
Total	19	2	10.5	28	7	25.0	19	4	21.1	2	1	50.0

Table 1: Frequency of carious deciduous teeth (C) by age.

Results

The age distribution of dental decay by tooth type is shown in Table 1. The youngest age category, .5 to 2.5 years, had a low frequency of decay that involved only mandibular first molars. The 2.5 to 4.5 year age group had the highest incidence of carious teeth and different teeth were affected including the maxillary second incisor and first molar and the mandibular canine and first and second molars. In the 4.5 to 9 year age interval only the maxillary second molar and both mandibular molars displayed lesions. Among 10 to 14 year olds, only one remaining mandibular second molar was noted as carious.

Throughout each age interval, molars displayed the highest frequency of lesions. The mandibular arcade showed equal or higher percentages of caries per tooth relative to maxillary teeth. In pooling all ages and teeth, the subadult caries frequency was 17.3% (21/121). The use of the tooth rather than the person as the unit of measurement ignores the question of intra-oral correlation of caries experience. It therefore is useful to tabulate the number of individuals with decayed teeth at each age. The distribution was as follows: 0.5-2.5 years, 2 with decay, 6 total; 2.5-4.5 years, 4/5; 5-9 years, 4/8 and 10-14 years, 1/4. Approximately one-half (52.4%) of the children recovered with erupted deciduous teeth showed evidence of caries.

Comparative data for deciduous dentitions of early world populations are rare. Of note, however, is evidence that the Easter Island deciduous caries rate of 17.3% exceeds frequencies reported for European populations (Table 2).

Date	Location	Number of teeth examined	Percentage of teeth carious
Bronze Age	Hungary	-	5.0
Frankish	Ciply and Spy, Belgium	100	11.0
Frankish	Coxyde, Belgium	116	1.7
Frankish	Achet	134	5.9
Merovingian	Belgium	325	3.6
Merovingian	Germany	368	3.0
Slavic	Moravian	2082	2.7
Medieval	Sweden	129	5.4
Hunnish	Mözs, Hungary	80	3.7
(after Wells 1975)			
Easter Island	17-1800 A.D.	121	17.4

Table 2: Caries rates of deciduous teeth.

DISCUSSION

The frequency of dental pathology in the deciduous sample was high when compared with early Europeans. In an earlier study that examined the adult frequency of caries (27.1%) among Easter Islanders, the adult series was also above European values (Owsley, Mires and Gill n.d.). High frequencies of carious lesions in both the permanent and deciduous teeth of Easter Islanders probably is attributable to the diet of this island group.

The contact population depended on gathered and cultivated foods. Cultivated foods were predominant and included sweet potatoes, taro, yams, ti, sugar cane, bananas, gourds, turmeric, and arrowroot (Metraux 1940). The antiquity of these plants is uncertain, but according to legend the island founder, Hotu Matua, brought to Easter Island all plants formerly cultivated. The population sample examined in this study dates to A.D. 1700. The diet recorded for the contact population applies well to this archaeological sample.

The subsistence diet was dominated by high carbohydrate foods, which were baked in earth ovens and eaten unpounded. Processing required large quantities of fresh water which were scarce (Metraux 1940). To overcome the natural limitations of available fresh water, the natives used the sweet juices of the sugar cane stalk as a liquid subsistute. Up until the 1900s, islanders consumed quantities of the sweet juice to relieve thirst, expecially during journeys and at feasts (Metraux 1940). The high carbohydrate diet, with its sticky consistency, and the presence of a natural sugar that was heavily exploited, was conducive to a high caries rate for all age groups and tooth types among the islanders.

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REFERENCES

Brabant, H. and H. Brabant. 1962. Contribution a l'étude de la paleo-pathologie des dents et des maxillaires: La denture en Belgique à l'époque néolithique. Bulletin de l'Institute Royal des Sciences Naturelles de Belgique. 79:105-41.

Gill, George W. 1981. Preliminary report of the 1981 Easter Island Anthropological Expedition. Unpublished field report to National Geographic Society, Washington, D.C.

Johnston, F.E. 1962. Growth of the long bones of infants and young children at Indian Knoll. American Journal of Physical Anthropology. 20(3):249-254.

Metraux, Alfred. 1940. Ethnology of Easter Island. Bernice P. Bishop Museum, Bulletin 160, Honolulu, Hawaii.

Owsley, D.W., A.M. Mires, and G.W. Gill. n.d. Carious lesions in permanent dentitions of protohistoric Easter Islanders. Ms. on file at the Department of Geography and Anthropology, Louisiana State University, Baton Rouge.

Schour, I. and M. Massler. 1944. Chart. Development of the Human Dentition. Second edition. American Dental Association, Chicago.

Turner, Christy G., II. 1979. Dental anthropological indications of agriculture among the Jomon people of central Japan. American Journal of Physical Anthropology. 51:619-636.

Wells, Calvin. 1975. Prehistoric and historic changes in nutritional diseases and associated conditions. In Progress in Food and Nutrition Science. 1(11):729-779. Pergamon Press, Great Britain.